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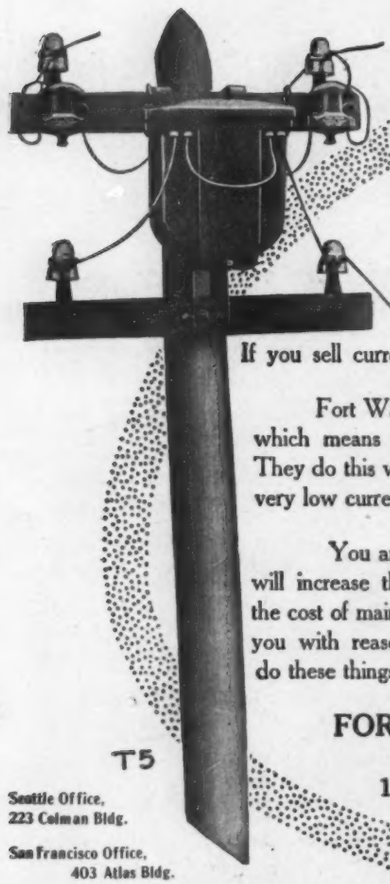

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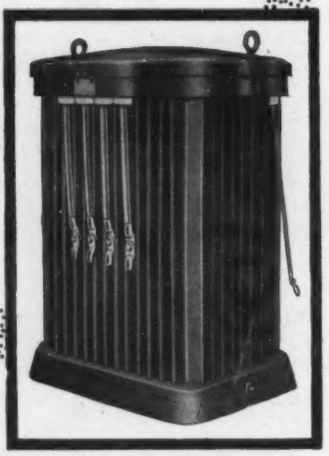

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SPOKANE'S ELECTRICAL PUMPING STATION

BY ALEXANDER J. LINDSAY.

The question of water supply for any municipality is an important problem. This is especially true if the city is rapidly increasing in population and provision must be made for future growth. One of the best examples illustrating this problem is the city of Spokane, Washington, which has just completed the fifth addition to its pumping stations within 26 years.

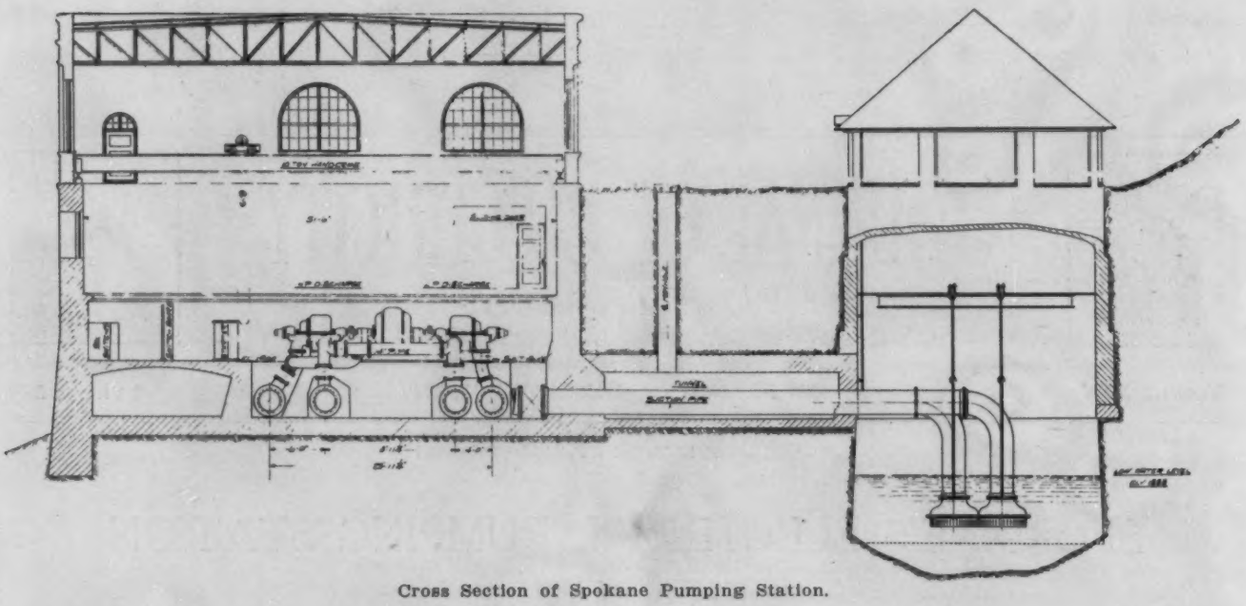
The growth of the city was up the river toward the east and the city grew so rapidly that in 1894 the original station had become so inadequate and the waters of the river so exposed to pollution that it became necessary to build a better and larger plant five miles above the center of the city. At this point the river had a natural fall of about 14 ft. At the upper

Exterior of Spokane Pumping Station, New Electrically Operated Addition On the Right.

The original settlement of Spokane was made on the Spokane river at the site of Spokane Falls. The original public water supply was built in 1884, and consisted of a small pumping plant situated in a flour mill. A few hundred feet of pipe were laid through the most populous part of the village. These pumps had a capacity of 350,000 gal. per day and were operated by hydraulic turbines which received their power from Spokane Falls. It is interesting to note that this original equipment is still in service doing duty as a portion of the newer and enlarged system. It serves to supply water from the low pressure system to the highest points of the city, which have rapidly grown as a residence section. However, these will soon be displaced by motor driven two-stage centrifugal pumps, which are to be installed.

end of this fall a rock-filled dam was built which somewhat increased the head and also provided a certain amount of storage. The water from this pond was carried through an earthen ditch for about a quarter of a mile to the gates immediately above the pumping station. From here the water was conducted by means of riveted steel flumes, 12 in. in diameter, to a series of vertical turbines, which were connected to pumps on the floor above by means of shafting and gearing. As this plant was far above the city the river water was absolutely free from contamination. The plant had a capacity of 10,000,000 gal. daily, which at that time was considered ample for Spokane for many years to come.

The adequacy of the water supply was based upon the experience of eastern cities and their normal factor



Cross Section of Spokane Pumping Station.

of growth. But Spokane grew much faster than the ordinary community and as early as 1898 it was necessary to add a new 4,500,000 gal. pump. This addition helped out temporarily, but in another four years it was necessary to add two 2,500,000-gal. pumps. These were driven by the same turbines which operated the original pumps for it was found that the wheels had ample capacity to carry the added load.

As the city grew, the hills south of the business section were soon occupied and, as the elevation of these was too great to be served by the same system which furnished water to the rest of the city, it became necessary to build two auxiliary pumping stations, one at Fifth avenue and Pine street and the other on Bishop Court near Monroe street. These supplied 2,500,000 gal. a day from the low pressure system to the hill section. These pumps were driven by electric motors. An attempt was made to instill high pressure pumps in the main station on the river bank but it was found that the old low pressure force main was not capable of withstanding the high pressure necessary to reach the hill sections of the city. At the time this attempt was made a new 30 in. riveted steel low pressure force main and a 20,000,000 gal. reservoir were built for the low pressure service and four 2,500,000 gal. pumps were installed in the river station. The addition of these pumping units carried the total capacity of this system up to 29,500,000 gal. per day and the low pressure system of the city was in splendid shape so far as quantity was concerned.

During all this time the valley of the Spokane river was being rapidly settled and the small town of Coeur d'Alene, situated where Lake Coeur d'Alene empties into the Spokane river, was rapidly becoming a city. This condition existing above the point where the water supply for Spokane was secured naturally tended to jeopardize its purity and city officials eventually found it necessary to condemn the source of water supply. At first it seemed probable that a new and entirely different source would have to be sought and the existing pumping stations abandoned.

During the construction of the up river pumping station it became necessary to dig pits for placing foundations and it was found that the water rose in these pits to a considerable height suggesting that there was a source of water supply either entirely separate from the river or else being supplied by infiltration. When it became necessary to seek a new supply a thorough investigation of the quantity and character of the underground water supply was made. Test wells were sunk at various points from Coeur d'Alene Lake down the river to the water works. Analyses of the water obtained from these wells showed it to be different from the water of the Spokane river. It was clear and pure and the only objectionable feature was the hardness. It was thought that a sufficient supply could be obtained from this source, but to make certain before too great an expenditure was made a large well 30 ft. in diameter was excavated back of the main pumping station. Two centrifugal pumps with a capacity equal to that of all the pumping machinery in the city were connected to this well and operated for a long time. While the level of the water in the well was lowered to some extent during pumping, it immediately rose when the pump was shut down and it was evident that the well had more than sufficient capacity to amply supply the city. This well was connected to the pumps in the river station and this supply was substituted for that from the river.

In the spring of 1908, the demand for water having again reached the capacity of the installed pumps, the two remaining wheels in the old station were loaded with two additional pumps of 2,500,000 gal. capacity each bringing the total capacity of the station to 24,500,000 gal. per 24 hours. While this helped out temporarily it was apparent that additional facilites would have to be supplied and plans were, therefore, put under way to meet the requirements.

It was decided that it would be best to dig a new well tapping the underground supply and to build an electrically operated pumping station, as the power supply obtained from the river was in use to its limit. The installation of these three motor driven centrif-

Motor--Driven Centrifugal Pumps in Spokane Pumping Station.

ugal pumping units has just been completed and is of particular interest as demonstrating the possibilities of this class of machinery for supplying water to large municipalities.

Pumping Station.

The new pumping station, which is entirely independent of the older station, is absolutely fire proof, being built with concrete foundations and steel and brick super-structure. It is supported on piling capped with a timber grillage all of which is below low water mark. The floor of the pumping station is itself 4 ft. below high water mark. In order to insure water tightness the basement floor and the walls, to a height of 7 ft. were made water proof by the use of asphalt felt and asphaltum. The interior walls are also made more impervious to the inseepage of water by being plastered with a coat of neat cement which also improves their appearance. The interior dimensions of the station are approximately 51½ ft. by 81½ ft.

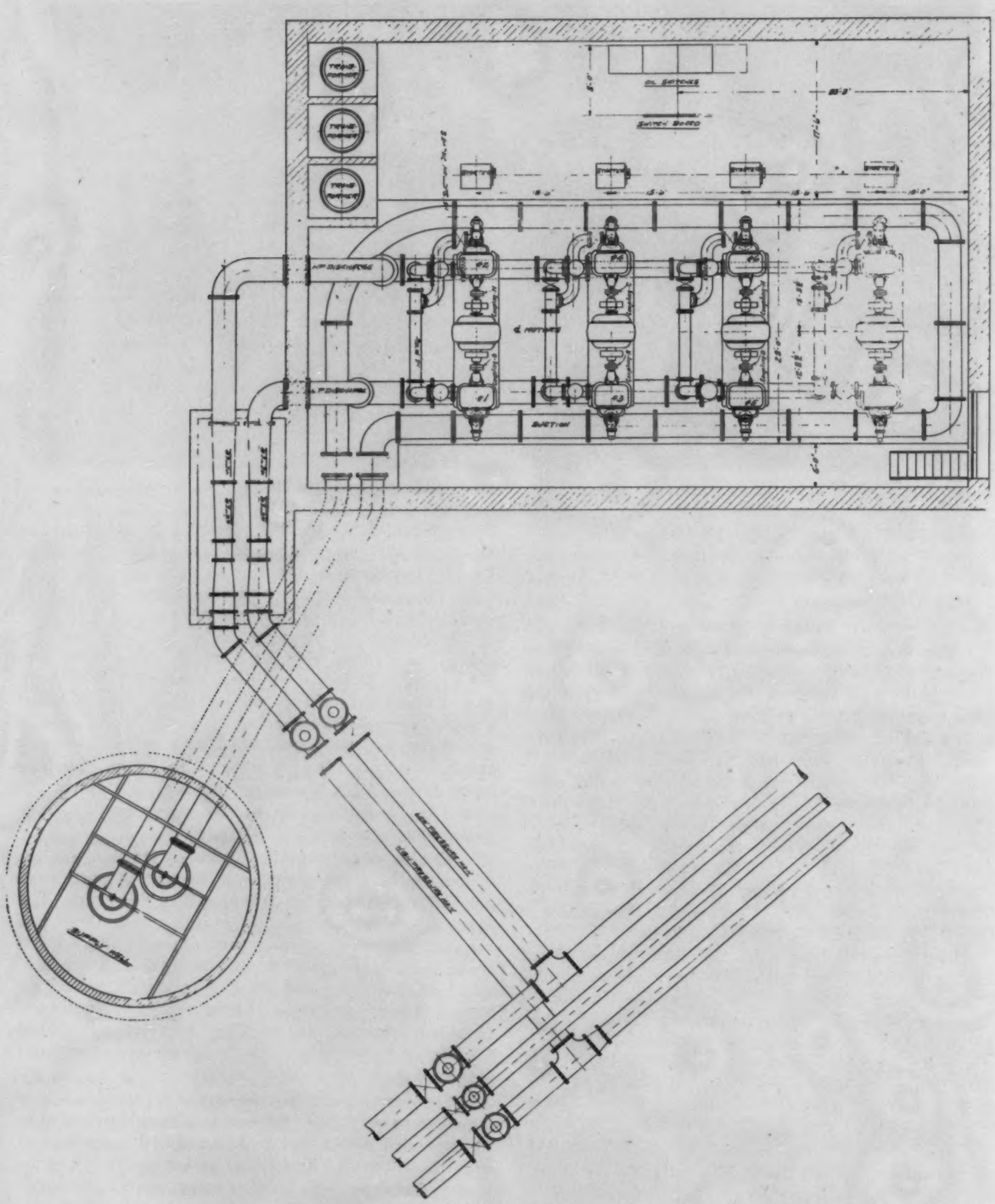
The three pumping units now installed are placed along one side of the station with their shafts parallel to each other and at right angles to the side of the station, as shown in the accompanying drawing. They are spaced 15 ft. 6 in. on centers. Each unit consists of a 900 h.p., 3 phase, 60 cycle, 2300 volt, 880 r.p.m. induction motor direct connected to two 14 in. two-stage centrifugal pumps.

Inasmuch as this equipment is representative of the most advanced procedure in this class of pumping equipment, a detailed description of both the pumps and motors may be interesting. Each centrifugal pump is of the Allis-Chalmers two-stage single end suction, horizontal shaft type. It is supported by brackets, cast integral with the casing, which rest upon and are bolted to a base plate. The shaft is made of open hearth steel and is amply large to carry the maximum loads without serious deflection. The impellers, which are of the enclosed type, are made entirely of bronze, and are fastened to the shaft by means of a feather key and nut. A bronze sleeve is also used to protect that portion of the shaft exposed to the action of the water. A stationary guide passage is placed between the two impellers, its function being to take the water from the tips of the vanes of one impeller and deliver it through suitably shaped passages to the inlet side of the succeeding impeller. The last impeller discharges in a radial direction through guide vanes into the casing. A balancing disc, connected with both the suction and discharge sides of the pump, maintains a practically perfect running balance. The bearings are of the ring oiled type lined with composition and the oil is supplied from a large oil reservoir. Stuffing boxes on both the discharge and suction sides of the pump are provided with bronze water sealing rings to prevent ingress of air.

The motors are of Allis-Chalmers standard design. They receive 3-phase, 60 cycle current at 2300 volts and will deliver 900 h.p. when making 880 r.p.m. The laminations, from which the stator core is built up, are suported in a substantial cast iron yoke which holds them securely in position. Cored openings are provided in this yoke and allow free circulation of air around the core and coils. Large ventilating ducts are provided. Special care is taken with insulation, and the copper is so designed as to give a very cool running motor.

The starting devices furnished with each motor include a bank of cast iron resistance grids mounted in an expanded metal case and arranged for connection with the collector rings. The resistance of the grids is such that a period of two minutes may be consumed in bringing a motor up to full speed with a temperature rise in the resistance not exceeding 175 degrees. The starters cut out this resistance in steps to secure proper acceleration of the motor. The collector rings are short circuited by a manually operated device when the motor is up to full speed.

Heavily insulated lead covered cables placed in the concrete floor connect the motors to the switchboard. Similar cables carried in conduits in the wall



Plan of Spokane Pumping Station.

of the building connect the transformers to the switchboard.

As will be noted by reference to the drawing, the switchboard is situated at one side of the station with the high tension oil switches in concrete cabinets back of it. The transformers are placed in one corner of the room. The switchboard is made up of four panels of blue Vermont marble mounted on an iron frame work which leaves a space of 25 in. between the bottom of the board and the floor. On the switchboard are mounted an ammeter, an integrating wattmeter, a volt meter and various other necessary instruments. Three 1000 k.v.a oil insulated water cooled single-phase transformers change the 13,200 volt line

current to 2300 volts for the station service. Taps are provided on both windings which give approximately 3, 6 and 9 per cent lower voltages. Transformers are connected in delta with a grounded neutral so that if one should fail it can be disconnected by means of switches and the station operated at one-half capacity on the two remaining transformers.

Piping.

From the supply well two suction pipes, arranged with foot valves, lead to the station and form a loop around the pumps. If it should be necessary at any time to repair one of these lines the total water supply of the station can be taken from the other. The suction pipes are carried from the well to the station through a concrete tunnel which is sufficiently large to allow for inspection and repair of the piping. The two 30 in. suction pipes are of riveted steel with flanged joints.

The discharge pipes are all of cast iron and are arranged with flanged joints throughout. By examining the drawing showing the station layout it will be seen that ordinarily both pumps of a set will discharge to the low pressure main. With this arrangement each unit has a capacity of 12,000,000 gal. per 24 hours against a head of 260 ft. However, in case of fire or other necessity for a higher pressure, the discharge from one pump of the unit can be connected to the suction of the other pump in which case the discharge of the second pump is led to the high pressure main. Under these latter circumstances the units have a capacity of 7,500,000 gal. per 24 hours against a head of 430 ft. Venturi meters are placed on the discharge of both the high pressure and low pressure lines.

Although the station was designed for four units only three have as yet been installed and the fourth will be placed in position when needed. After operating the station for a short time in a preliminary way to properly make adjustments, it was put in regular service and has been delivering water to the city for about two months. Every one who has been connected with the work has been extremely gratified with the success which has attended this electrical pumping equipment. The pumping units operate with practically no vibration and are easily regulated to maintain any desired pressure.

ELECTRIC VEHICLE PUBLICITY.

The Electric Vehicle Association of America has appointed a publicity and advertising committee whose purpose is to increase the use of the electric vehicle by advertising in the popular magazines and the trade publications. Money for this purpose is to be solicited from central stations on the basis of 1/25 of 1 per cent of the gross income of each company, a like amount also being anticipated from manufacturers. This committee consists of N. F. Brady, Samuel Insull, J. B. McCall, C. L. Edgar, W. W. Freeman, Charles R. Huntley, Alexander Dow, George H. Harries, Samuel Scovil, F. W. Frueauff, H. M. Byllesby, J. G. White, A. H. Ford, T. N. McCarter, Thomas Dolan, R. F. Pack, Arthur B. Lisle, Marcy L. Sperry, R. M. Searle, John B. Miller, John A. Britton, Alton S. Miller, G. W. Brine.

WATER POWERS OF SOUTHERN WASHINGTON.

Water Supply Paper 253 from the U. S. Geological Survey and written by J. C. Stevens is the first of a proposed series dealing with the water powers of the streams flowing from the Cascade Range in Washington and Oregon. Perhaps no area in the United States presents more favorable opportunities for water-power development than that traversed by the Cascade Range. The general elevation of the summit of the range is from 6000 to 8000 feet, and many of its peaks extend into the region of eternal snow. Among these peaks are Mount Baker (10,827 feet), Mount Rainier (14,363 feet), Mount St. Helens (9750 feet), Mount Adams (12,307 feet), Mount Hood (11,225 feet), Mount Jefferson (10,300 feet), Mount McLaughlin or Pitt (9760 feet), and Mount Shasta (14,380 feet). The streams draining this range have steep slopes and are fed during the low-water period by the many snow banks and glaciers that mantle the high peaks or by the liberal supplies of ground water. The precipitation on the area is abundant, although its distribution is by no means uniform. The streams possess the requisite properties of water-power development—rapid fall, abundant water, and comparative uniformity of flow; and the almost unlimited resources of timber, mines, and soil, as yet hardly touched, afford a promising market for these water powers and fixes for them a high potential value.

The primary source of rainfall in the Pacific States is evaporation from the Pacific Ocean, the water vapor being carried over the land by prevailing westerly winds. Whenever the moisture-laden air is cooled below the point of saturation, rain falls, and no precipitation can occur unless the air is thus cooled. The temperatures over the ocean are not nearly so variable as those over the land. In summer the land is relatively much warmer than the ocean, while in winter the reverse is true. Hence the general tendency is for the water vapor to be carried eastward over the mountains in summer and to be precipitated on them in winter. Thus we have the wet and dry seasons.

When the air in its eastward course encounters the western slope of the mountain ranges it is deflected upward into regions of diminished pressure. The resulting adiabatic expansion cools the air and the water vapor is precipitated. Thus the rainfall on the windward side of the range is much greater than on the leeward side, while the maximum rainfall probably occurs just over the divide. The summit of the Coast Range receives about 150 inches of rainfall in a year and the Cascade Range about 100 inches. Only about 5 per cent of this falls during the summer months, so that during this period the streams draw upon water stored in the ground and in snow banks and glaciers during the previous winter. The low-water period therefore occurs just before the fall rains begin.

The area treated in this paper comprises the drainage basins of Klickitat, White Salmon, Little White Salmon, Lewis and Toutle rivers and is located in the southern extremity of the Cascade Range in Washington. The broad crest of this portion of the divide lies wholly within the Columbia and Rainier national forests, within which all streams of the region have their sources.

Special investigations made on these streams during the season of 1909 form the basis for this report. Each of the streams investigated is considered in detail. Descriptions of the several drainage areas are given, together with profiles of the streams and principal tributaries, discharge data, and a detailed compilation of the water powers capable of being developed at the average minimum stage. The report must be considered rather as an inventory of the latent power resources of this section than as an engineering report on feasible power projects. It is, however, based on engineering principles, and the present practices of water-power development have been given due consideration.

The field investigations were made by two parties of four men each, which were in the field from July 1 to October 1. One party, in charge of H. D. McGlashan, junior engineer, United States Geological Survey, made the surveys of Klickitat, White Salmon, and Little White Salmon rivers. The other, in charge of C. W. Harris, instructor in hydraulics, University of Washington, made the surveys of Lewis and Toutle rivers. Warren O. Harmon, Charles Leidl, F. W. Whalley, and C. F. Holmes, students at Washington State College, were employed as rodmen. A map and a profile of each stream were made and data were gathered as to the discharges at critical points in each drainage area. From these data the undeveloped water-powers have been computed. Except for a 200-h.p. plant at Husum, on White Salmon River, there are no developed powers on any of the above-named streams.

In presenting the power statistics the average minimum flow of the streams has been used. The average minimum may be defined as the mean discharge for the lowest week in each year, averaged for a succession of years, say ten. The absolute minimum in a ten-year cycle might be as low as a third or a fourth of the average minimum, but it would continue only for one or two days, possibly only for a few hours.

Summary of Results.

Klickitat river leads all others in this region in opportunities for water-power development. Seventy-three miles of the main river were surveyed with a range of 3255 feet elevation.. The river next in importance is the White Salmon, with a fall of 2660 feet in 32 miles. Lewis river was surveyed for 51 miles, in which distance a fall of 1495 feet was found. Toutle river is 54 miles long, the entire length being mapped. It has a fall of 3153 feet. Little White Salmon river is of secondary importance. The discharge is low, but the stream has a steep grade, a fall of 1285 feet being found in the 8 miles surveyed.

The following table gives a summary of the data obtained during the season of 1909 in this region. The total horsepower for the average minimum discharge of the streams as surveyed is 386,500.

SUMMARY OF WATER-POWER SURVEYS.

Stream system	Miles surveyed.	Total h.p. for average minimum discharge.
Klickitat	81.2	154,000
White Salmon	34.2	105,000
Little White Salmon	8.1	5,500
Lewis	65.0	78,000
Toutle	59.6	44,000
	248.1	386,500

It would probably be safe to add about 8000 h.p. for small tributaries and portions of the main streams not surveyed, giving in round numbers 395,000 horsepower for the streams named above. The principal streams not surveyed in this region are Wind River, Washugal River, Salmon River, South Fork of Lewis River, Kalama River, South Fork of Toutle River, and Green River. The aggregate power on these streams at low stage is probably not over 30,000 h. p., making a grand total for this entire area of 425,000 h.p.

It has been estimated from very meager data that the total water-power in the Columbia river basin will aggregate 10,500,000 horsepower at the average minimum stage of the rivers. The possible water-power development of the region under discussion, therefore, is only 4 per cent of this total. At present the water-power plants in operation in the State of Washington have an aggregate rated capacity of about 81,000 horsepower, so that the possible development in this region is five times that already developed in the State.

Conditions Governing Hydraulic Development.

From the standpoint of the public an answer to the question, "How much water-power is there on a certain stream or in a certain territory?" is of great importance. In areas where great water-powers are known to exist and public-service corporations are appropriating them as fast as or faster than a market for them grows, the interest of the public in their development becomes a paramount issue.

The long-distance transmission of electric energy has changed our perspective of this resource amazingly during the last ten years. A few years ago the use of water-power was limited to the immediate locality where it was developed. Now a hydroelectric plant can serve the industrial and community needs of an area 200 miles or more from it. This fact makes water-power a public utility. The natural laws that govern the development of hydroelectric powers and the social and industrial conditions that supply the market for them make consolidation and community of interest among those engaged in their operation inevitable. In the operation of power plants for public service it is of prime importance that continuity of service be assured. The natural conditions of stream flow make it almost impossible for a single plant depending on water-power alone to insure continuous service. Hence the necessity that one company should operate several plants.

The requirements of power consumers are by no means uniform. They vary from hour to hour, from day to day, and with the seasons. This non-uniform consumption requires that a certain reserve be maintained at all times to meet "peak loads" during the day and

for regular and extraordinary demands that arise from time to time. Hence even where one company operates several plants it is virtually required to maintain auxiliary steam plants to be used in connection with the water-power plants.

From the standpoint of the consumer also, whether an individual, a company, or a municipality, there is every advantage in having the sources of power under one administration. Efficiency in operation and economy in consumption therefore demand consolidation of interests. Such a consolidation, which makes for conservative and efficient use of the natural-power resources, should not be prevented. The public concern, therefore, must be aimed, not toward prevention of consolidation, but toward prevention of the harm to the public interest that might result from an unscrupulous administration of such a consolidation. The solution appears to lie in a wise legislative regulation of the manner in which power privileges shall be acquired and power plants maintained in order that the consumer shall be assured the necessary energy at a reasonable cost, consistent with a just and reasonable income on the investments by the power companies.

The factors that govern power development are three—(1) the volume of water available, (2) the fall through which this water can be utilized, (3) the market for the power when developed.

A project is feasible or not according as these factors are favorable. The market feature is, of course, independent of the other two and is subject to evolutionary laws. Therefore in a public inquiry such as that covered by this report it is necessary to consider only the physical features of discharge and fall, and to include all portions of a stream where such features make power development possible. Yet a consistent regard must be had for practicability of development, and some standard of comparison must be adopted.

In developing power plants it is profitable to install power units for a much larger amount of power than that represented by the minimum flow of the stream, for it is always necessary to have auxiliary steam plants which can be used to tide over a period of shortage of water and are called on for the peak loads. The interest, depreciation, and maintenance charges of a steam plant must be carried in conjunction with the fixed charges on the water-power plant. Hence the excess of power capacity which it is profitable to install over that afforded by the stream in extreme low water will depend on the relative cost of steam and water-power and on the peculiarities of the particular market served. This excess may vary from 50 to 300 per cent.

In presenting general power statistics it is impossible to estimate this excess, and all that can be done is to state the power for the average minimum discharge of the stream and the known fall. The theoretical power thus obtained is arbitrarily reduced 30 per cent to represent "brake" horsepower, or the power that could probably be delivered to the turbine shafts. Where special studies are made the figure so derived can be increased or reduced according to the exigencies of the case.

PROSPECTS FOR NEW PRODUCTION OF GAS MAKING OILS.

BY P. W. PRUTZMAN.

(Concluded)

Coalinga (See Map No. 5).

In this field we have two sub-districts, one entirely separate, the other two not yet joined, though work is proceeding in that direction. The little Home pool was long ago marked out by a complete ring of dry holes, and there are no prospects whatever for extensions, so far as the immediate neighborhood is concerned. Two rigs are at work back of the heavy oil territory, in hopes of finding extensions of the "Home Sand," and the deeper of these holes has reached a depth which should bring it close to this sand, if in place. No results are yet reported. Home oil is a green oil of 32 degrees gravity.

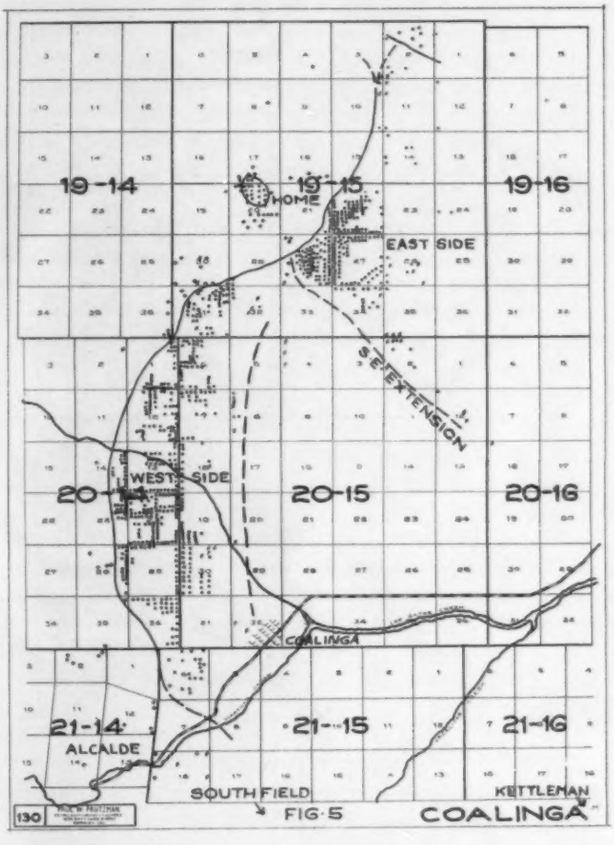


FIG. 5

Any northern extension of the East Side field seems to be stopped sharply by several deep failures on Section 2. Whether an extension will be found to the northwest is problematical, though some work is being done in that direction. Between this limit and the main East Side field there is quite a strip of proven territory, but this is almost entirely in the hands of two large corporations, and does not cut much of a figure in immediate calculations. To the east no limit can yet be set, but wells in this direction are rapidly growing deeper, and even now are reaching the limit of profitable drilling. The same may be said of the work down the Coalinga anticline, or South East Extension. A large amount of excellent territory has been opened up by the work done in the last four or five

years, but drilling is so deep that development is necessarily slow.

In the main portion of the East Side field, two sections to the west are largely drilled up, and are sharply marked at their western side by the cropping of the formation. At least one very deep well failed to find a lower sand, and while there is considerable territory a little farther east yet waiting for development, I do not believe that considering all the conditions, more work will be done at present price of crude than will maintain production level. I look to see the production in this part of the field, taken as a whole, remain about stationary so long as present market conditions continue, though it could undoubtedly be increased to meet a more active demand.

In the West Side field we have shallower wells, as a rule, and a much greater number of operators. This group is pretty plainly marked off at its western edge by the cropping of the formation, and so far the wells drilled in the older rocks farther back have not been successful. At the northeast there is still room for a small extension, if it should be found that the sands continue to be productive across 28 and 32-19-15. On the southeast, two wells on 20 and 32-20-15, though both had oil, do not seem to encourage work farther out, as both were quite deep and had quantities of water at the bottom. Further north, along the west line of Section 8, work done lately has been quite successful, but the ground east of this does not look promising, as a very deep hole on Section 4 has not shown up anything. I have marked in this limit as doubtful, but do not believe that much production will be had to the east of it until the apex of the Coalinga anticline is passed.

At the south end section 6 appears to be about the limit, though it is possible that parts of 7 and 8 are good—these are both tied up, and no work is being done. Work in the Alcalde group has resulted in entire failure, and nothing is to be expected in this direction unless it is found that the sands of section 6 extend back as far as 18.

Even the bounds set leave a large amount of undrilled territory, capable of heavy total production, but I do not believe that any particular increase of output at present prices is imminent. Most of the smaller companies, who are the most likely to force production onto a falling market are along the back edge, where the new work has not been profitable, and where the possibilities of large production are limited. Most of the vacant territory to the east, where drilling is deeper and production larger, is in the hands of large operators who will certainly see their interest in holding production down to what the market can absorb.

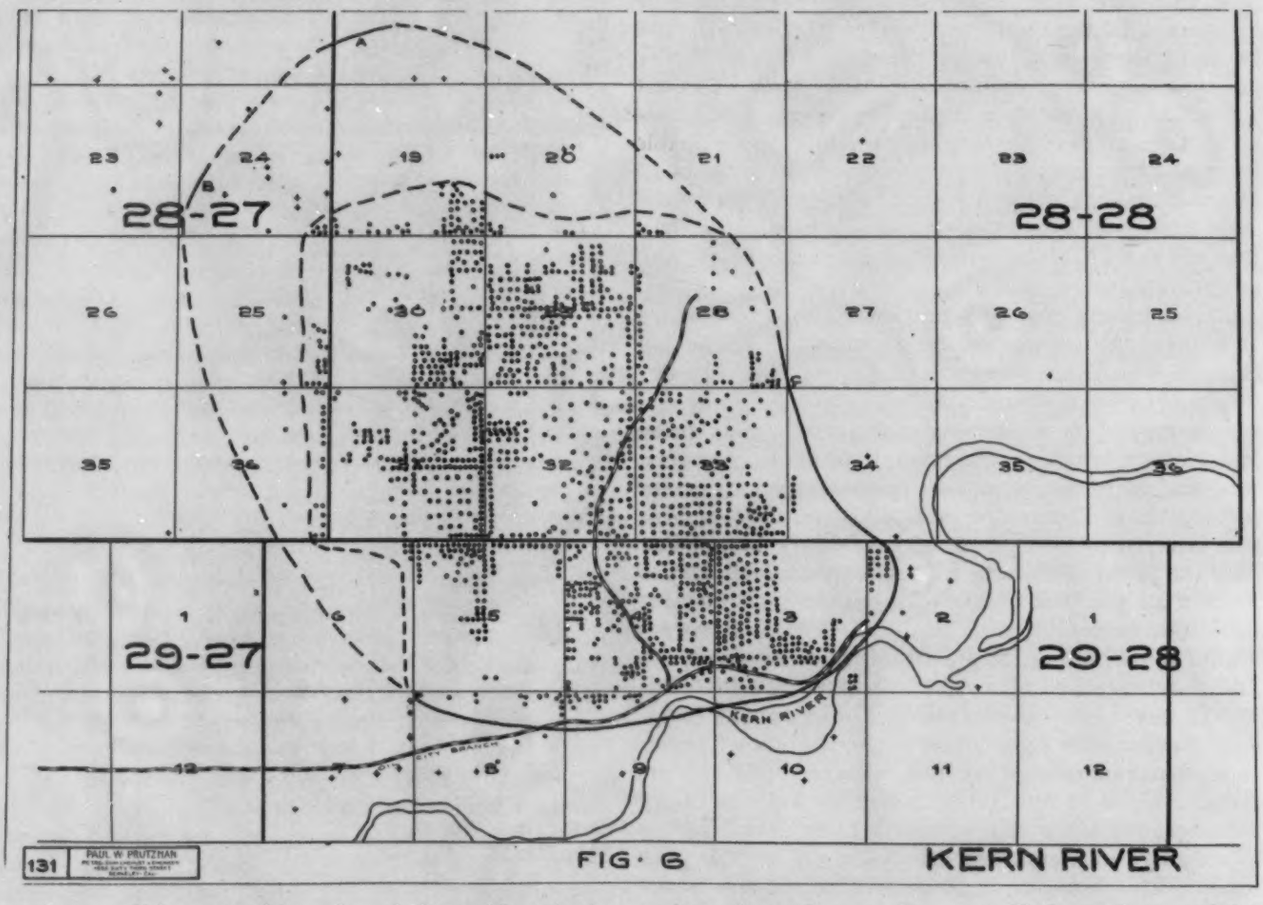


FIG. 6

One the whole, while Coalinga has undoubtedly large capacity for new production, which can be drawn on at any time, I do not believe that the production will be allowed to increase materially, if at all, while prices remain as at present.

South of the Coalinga field, some work is going on in Jacalitos and in the Kettleman Hills. One well in Jacalitos has reached a great depth, and is said to show very good indications, and in Kettleman the prospects are good for the opening up of some new territory. In either case, however, anything new will

be very deep, and development correspondingly slow, so that we have no reason to expect anything which would influence prices for some time to come.

Kern River (See Map No. 6).

On reference to this map you will notice two dotted lines, coalescing to a single solid line. The latter marks the lower limit of the field, beyond which production cannot extend, and plainly shown by a number of dry or valueless holes. Two of these were very deep, and failed to find a lower sand, and a well now drilling on the bluff south of the river does not indicate any prospects in this direction.

The inner dotted line, taken in connection with the solid line, bounds the positively proven area, and all parts of the area included are capable of what is called good production in this field, where wells are shallow and cheap. Within these limits there are still large vacant areas, which are probably capable of about as much production as any other parts of the field, though it is likely that near the edges wells cannot be spaced so closely as in the heart of the proven area.

Between the two dotted lines is a second area now giving some production in parts, and probably capable of producing more or less oil over most of its extent. Just how valuable this territory may be remains to be proven—only a small number of wells are now pumping, and operations here have met with some drawbacks.

Outside of the outer dotted lines any production of value seems doubtful. Certainly the field is limited to the east, at the point "C," and just beyond the points marked "A" and "B" are failures of sufficient depth to put a damper on any further work in this direction.

In spite of the enormous output from this field in the past, the wells have proven steady, and a comparatively small amount of new work has sufficed to maintain production. How long this will continue cannot be stated with certainty, but it is probable that no decrease is in sight for some time to come, unless it be a voluntary one. On the other hand, it is safe to say that there will be no sudden increase, as the production of individual new wells is quite small. a good deal of the territory in the heart of the field is in the hands of parties who develop slowly, and a great deal of new work would be required to bring about any increase which would effect the general situation.

McKittrick-Sunset Territory (See Map No. 7).

At McKittrick the west side of the field, and a good portion of the eastern margin, were long ago marked out by a line of dry holes, and attempts made lately to extend the main field to the east, resulted in entire failure. Dry holes limit also the north and south ends of the strip, and there do not seem to be any hopes of extension of already proven ground, nor of a connection with the Midway field.

Considerably east of the main field, a couple of rather shallow wells have lately developed some very heavy oil, about 12 degrees, but the production per well is small, and this territory is not generally considered very promising.

The little group southeast of the main field seems to have struck a sort of stray sand, and the production is small. These wells were drilled about ten years ago, and no attempt has ever been made to extend this group.

Though the area of the McKittrick field is small, the wells are as a whole productive and quite dependable. It is probable that the production of this field will remain about constant for some time, and then gradually decrease.

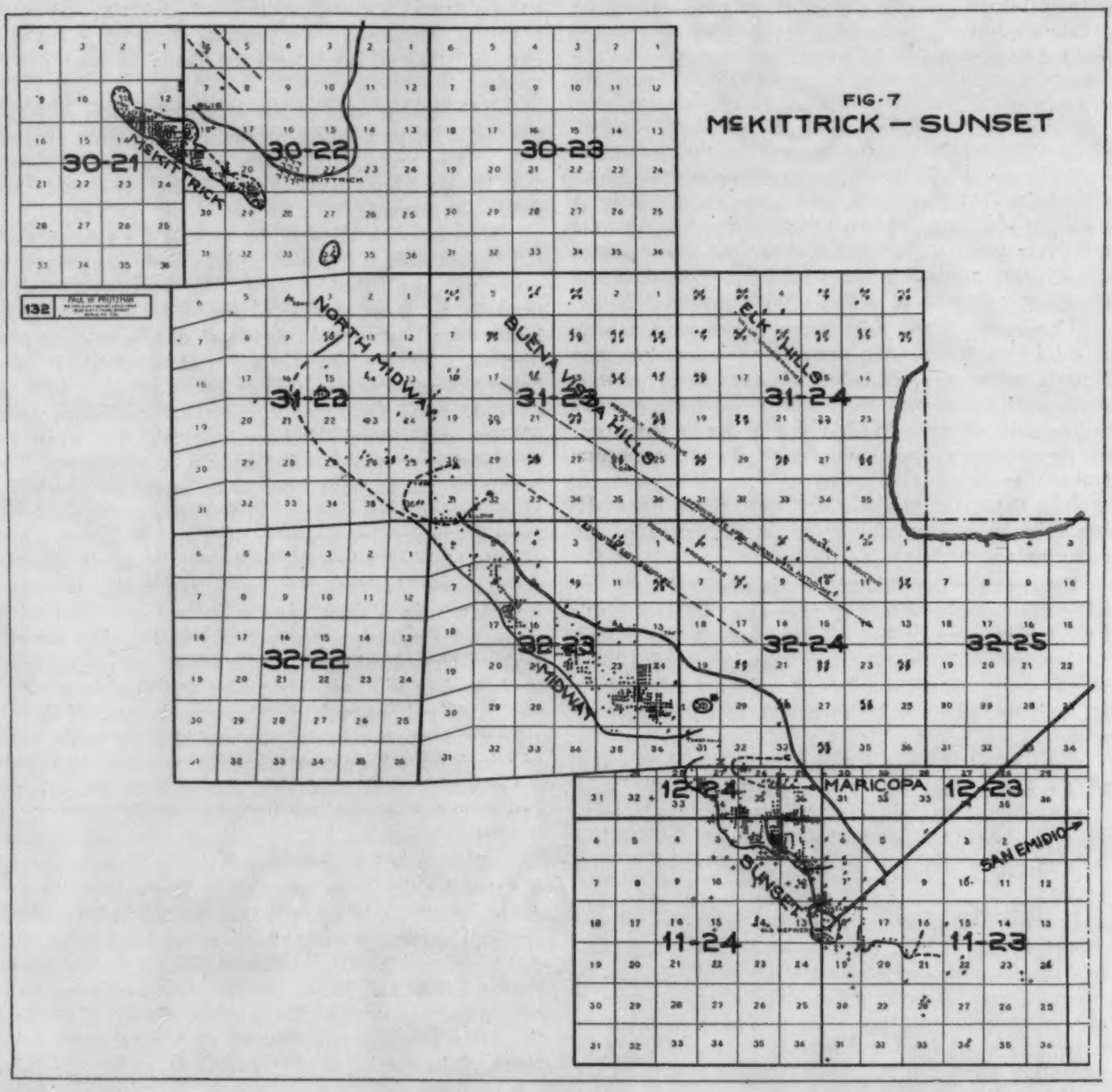
Now passing Midway, let us look for a moment at old Sunset field. The bulk of this field was developed years ago, and the limits to the southwest plainly marked by a large number of dry holes. Close to these limits the wells were, as a rule, shallow and quite productive, a hundred barrels a day from an 800 ft. well being not uncommon—this of an oil ranging from 11 to 14 degrees. On account of market conditions, most of these wells stood idle for a long time, but when put to producing rapidly dwindled to a small output. The reason seems to have been that, while the thickness of producing sand was not great, these wells produced from a coarse sand under a high gas pressure, which rapidly blew off when the wells were opened. Farther south, near Hazleton Station, a few wells developed lighter oil, in a finer sand with less gas, and while these wells were less productive initially, they are still making considerable oil, while many of the heavy oil wells spoken of have been pulled and abandoned.

Still farther south, near and to the east of the old refinery, are a number of pits and shallow wells, some of which have been producing for as much as twenty years, and are still profitable. These wells were always small producers, and had little or no gas.

The Sunset field is peculiar among the oil fields of California in being spotty. Even in Ventura, which is noted for the irregularity of its formations, the producing sands, while small, are usually of a definite lenticular form, or in some cases are limited by their steep inclination. But in Sunset the producing formation is folded and faulted in the most confusing manner. While less true of the western margin of the field, this is to some extent true of all the territory lying south of the north line of township 12, so far as drilling has been carried.

For instance, starting at the center of the west line of 1-11-24 and going north, we find the depths of wells to vary from 1100 to 3000 feet, and that not evenly but in such manner as to show three shallow spots, with two deeper troughs between. There is also a wide variation in the productiveness of these wells, which does not correspond with any recognizable position on the folds. This folded condition of the formation extends to the Lakeview well, or at least to the point where drilling has been carried, which is less than a quarter of a mile from that well.

Going east from the same starting point we find the depth of wells to grow regularly and slightly greater, with a considerable increase in productiveness, to the east line of section 1, where there is either a sharp fold or a fault. A well just over this line went 2000 feet or more to the tar sand, and has never produced, a second is considerably over 2000, with nothing but water, and a third had some oil but no pay at 2400 feet or over. This while the wells a short distance west of the line produced heavily at slightly over



one thousand, and on section 32, a mile to the northeast, a healthy producer has been brought in at about 1600 feet.

All this may be considered beside the point, but to my mind it has a direct bearing on the prospects of the southern part of the Midway field. And it would seem that, so far as any immediate results are concerned, the future production figures of the State rest largely on the behavior of this field. For when we have set aside Cat Canyon, Lompoc and Coalinga, we have left nothing but Midway which offers any promise of an immediate increase in production.

Midway appears to be limited to the north by two wells which, though still drilling, have reached a great depth without any result, and are probably failures. To the west it is marked by a scattering line of dry holes, and while this shallow territory has by no means been drilled up, the limits appear to be fixed, approximately at least. To the east no present bounds can be set, and prospecting is going on over an area many miles in width, but at present with but one producer far outside proven limits. To the south this field joins the Sunset field.

The wells toward the northern and western margins of the field are comparatively small producers, that is, running in the hundreds rather than thousands of barrels. On the average, however, they are steady, and in spite of the spectacular performances of several flowing wells, the bulk of the production of the field, up to the time of the Lakeview, had come from these smaller wells. The enormous output of the Lakeview, and very lately of a couple of adjoining wells, has of course put the regular production quite in the shade.

The big gushers in Midway have, to the present, been found in three groups, one (see A, Fig. 7), embracing the Santa Fe well on 6-32-23, the Eagle Creek, Crandall, American Oil Fields No. 56 and 79, California Midway, Mays and Pioneer Midway. The second (see B, Fig. 7), is the Standard's group of three

wells on 30-32-24, and the third (see C-C, Fig. 7), covers the Lakeview, Sunset Monarch, American Oil Fields on 32-32-24, and probably the Consolidated Midway on 30-12-23. The latter, and the Obispo well on 32-12-23 cannot yet be placed with certainty as regards their relation to other large producers.

The per diem production of some of these wells is so enormous that we are warranted in examining their history and relations quite closely, as if these wells should continue to produce at their present rates, and if the "gusher sands" should be found to continue to any great distance, the question of the disposal of the oil would become a serious one.

The wells of the first group are almost an unknown factor, as few of them have been brought to steady production. As is well known, they produce enormously for a time, then "bridge" or choke with sand and lay off for a considerable period, so that only one or two have had a chance to run their natural course.

The Santa Fe well was finished late in 1909. Its production was originally about 2000 bbls. a day of 21 degrees oil, and has fallen to some 400 bbls. at last reports. The "Crandall" well of the Hawaiian Oil Company was finished at about the same time and rate of flow, and has fallen off to a small production, through by some is considered to be choked with sand. The American wells are yet too new to give any information, and none of the other wells in this group have ever produced steadily enough to give any idea as to their probable life. And as no wells intermediate in position have been finished lately, we do not know whether the draining of the sands by such heavy production has or has not rendered impossible the bringing in of similar wells between those already drilled. However, from the data at hand I think we may safely say that the limits of this group will not be outside of those indicated on the map. And it must be borne in mind that not all the wells already drilled within these limits are gushers, by any manner of means.

As to the Standard's group of wells on section 30, it may be said that all these wells flowed, but only one was a phenomenal producer, and it is probable that this well is something of a freak, and does not represent the productiveness of any large area. This well was finished in December, 1909, and is said to have flowed for three months at an average rate of 8900 bbls. per day, has produced steadily, and is now down to 1200 bbls. or less.

The history of the Lakeview is well known. It was brought in during March, 1910, as a wild well, and has produced steadily ever since. At the start its output was about 35,000 bbls. a day, it reached its maximum about thirty days later when it did nearly 65,000, and is now down to 18,000 or 20,000. This decrease is plainly due to exhaustion of pressure, and not to any extraneous cause.

The nearest well to the west is a Sunset Monarch well, about one mile distant, which was lately brought in at a very large rate. Just to the north of this is a well of the American Oil Fields, also new, and said to be doing about 20,000 bbls. Neither of these wells has had a chance to show its durability.

It is evident that the gusher territory does not extend much farther in this direction, as about half a mile to the west and in the same line are four wells, which are considered to have reached the same sand, and which, while good wells, are not at all unusual. This gives us an approximate western boundary for this group.

To the north of the Lakeview no work has been done, and we have no certain information as to how far in this direction heavy production may extend. Probably not very far, if we may reason by analogy.

The dip of the producing formation is here almost northeast, but by some geological freak the territory south of the north line of Township 12 is, or at least from the drilling records appears to be, crossed by a succession of folds lying almost due east and west.

The three wells above mentioned lie in one of the troughs thus formed, and their comparative depths indicates a slight dip to the eastward. The depth of the Consolidated Midway well on 30 also corresponds closely with the angle thus calculated. South of this trough the formation rises, and on the ridge thus formed several shallower producers have been drilled. None of these wells have been satisfactory, as while they had heavy initial production, this rapidly blew off. South of this ridge another trough is indicated, then another ridge, and this folded or faulted condition of the formation (the drilling records do not show which) extends indefinitely toward the south and southeast. All the wells in this direction from the Lakeview show the same behavior, that is, a rapid decline from initial production, when this is large, and a considerable variation in the value of closely adjacent wells.

Now it seems to me rash to assume that the broken condition of the formation, as demonstrated south of the township line, suddenly ceases at the Lakeview, and that north of this point we will find a blanket formation, of equal value at all points. Indeed the drilling records farther north all indicate the contrary, for near the center of the northwest quarter of 31-32-24 is a well considerably over 3000 feet, which lines up with good production on both sides, and yet was dry or practically so. Many examples of this could be given. For these reasons I think we are safe in placing the extreme northern bounds of this gusher strip as shown on the map, and my own opinion is that the strip as finally drilled up will prove to be much narrower, if indeed there is a strip at all, and not merely a succession of rich spots, arranged in an approximately straight line.

To the eastward no bounds can yet be set to this gusher strip. The Consolidated Midway well is undoubtedly a heavy producer, though being under control it has not yet given any indications as to its probable life. Beyond this no work has been done which could have any connection with these wells, and the Obispo flowing well to the south is about 500 feet shallower, produces a different grade of oil, and appears to be on a separate fold, if not on a different formation.

We have now shown, so far as the data will warrant, an actually proven area, another and larger area prospected but not proven, and have indicated as

nearly as may be the spots where large "gusher" production is indicated (this should not be taken to mean that other such spots may not be found). Let us now summarize the actual prospects for production from these areas.

As to the territory lying east of the actually proven strip, but little is known. Only one well is actually producing in this entire area, and this not a large one, though the gravity of the oil is high. The fact that this producer is on the east face of the Buena Vista anticline, coupled with the fact that the Standard's well on Section 26, which appears to be on the apex of the anticline, is a gasser, would rather lead to the belief that a strip west of the apex, and extending to an indeterminate line down the valley between the Buena Vista Hills and the main ridge, will be gas territory or barren. Perhaps this is a large assumption on slender grounds, and for the present we will have to class this strip as possibly productive. The east flank of the Buena Vista anticline is practically certain to be productive, though to what extent it is yet too soon to judge. As to the Elk Hills, we know nothing at all, and prospecting here is based strictly on geological indications. A great deal of work is now under way, and the future of much of this work, which is being done on reserved government land, is shadowed by doubts as to the ultimate policy of the Land Office. Still, considering all the circumstances, it is doubtful whether the final decision in these cases can be other than favorable, to at least such operators as commenced work prior to the last withdrawal order.

Within the strictly proven limits of the main field we find a large area of undrilled land, which analogy with conditions at Sunset, and work already done, lead to believe will be more or less productive over its entire area.

Further, we may fairly expect at least some extension of the territory giving heavy producers, and even those now drilled may be counted for a very large total output before they fall to the pumping class. And indeed it is quite within the limits of possibility that other such areas will yet be discovered in virgin ground. So that eliminating any possibilities in Buena Vista or Elk Hills, or in San Emidio, we have still to reckon with a truly enormous possible prodution.

I say possible production because, except in rare cases, oil does not bring itself to the surface automatically, but is under the control of the operator. This brings up the next question, and one of interest alike to the producer and consumer—whether this possible production will be restrained so as to keep the actual output within market requirements, or if this be not done, whether it is possible to so control the output as to maintain a price materially above production cost, in the face of a continuous over-supply.

That there is a very large over production, not merely in sight but actually existing, can hardly be questioned, nor that this excessive supply is definitely in sight for some time to come. It is highly probable that the Midway field alone could, within a few months, be made to produce enough oil to supply our entire local market. Whether this production can be kept within safe bounds, I greatly doubt. In the case of Elk Hills and Buena Vista, this restraint will probably work automatically, once the discovery wells are finished, as the bulk of this territory is in the hands of large operators, who will undoubtedly see their interest in holding down their output, at least so long as the slightest chance remains of maintaining the market. Sunset does not appear at present to offer any great hopes, and prospects in San Emidio are uncertain, and far in the future at best. But as to the main field at Midway, such restraint is doubtful, as a large part of this field, and some of the richest parts, are in the hands either of weak companies, forced by their needs to sell their product for what it will bring, or else of those to whom a low selling price is an advantage. I do not see how it is possible, considering the large available production, and the hands in which much of it rests, to seriously restrict the actual output of this field so long as the production of individual companies can be sold at cost or above.

This brings us to the last question—can this overproduction, once bronght to the surface, be controlled so as to keep the selling price much above production cost. I must admit that I do not know. The problem is one of great difficulty, but is being met by the producers with well judged and executed plans, and with a rare degree of fidelity to the common cause. I can only give you the facts in the case, as I see them, leaving a decision as to the outcome to your own judgment.

Bavaria represents about one-tenth of the total population of Germany, and yet has at its disposal only one-two-hundredth part of the total output of coal in the Empire. Therefore it is easily understood that it is of considerable importance for Bavaria to find an equivalent for the coal with which nature has not enriched the country, by the utilization of the existing extensive water power. It contains about 2500 electric generating plants, of which 2/3 are privately owned, 1/6 belonging to the limited liability companies, and the remainder are owned by the Government, by communities, and by co-operative societies. Nearly half of the total power (128,536 kw., or 46.7 per cent) is supplied by steam engines without any other reserve power. By the sole use of water power less than one-tenth of the total produce is gained. Water and steam participate with three-tenths (80,724 kw., or 29.30 per cent).

POWER SITES WITHDRAWN.

During 1910 great activity has been shown by the U. S. Geological Survey in the withdrawal of lands recommended by the Survey in aid of proposed legislation touching the use and disposition of water-power sites, the total of such lands withdrawn during the year amounted to 1,219,818 acres, thousands of western power sites being affected. The total outstanding power site withdrawals at the close of the year were 1,454,499 acres. The water-power problem is admittedly one of the most important for which legislation is asked. While the Survey has made withdrawals intended to conserve the water-powers of the public domain, the Director's report sounds the significant note of warning that no power sites should be allowed to be acquired for speculation under another guise.

THE PHYSICAL MEANING OF ENTROPY EXPLAINED.

BY A. L. MENZIN.*

A careful reading of the criticisms and comments of Prof. Durand[1] and others on the physical meaning of entropy as advanced by me leads to but one conclusion—that I have not succeeded in explaining to others the simple physical significance of this term which my first article[2] attempted to point out. Only the mathematical significance of my definition seems to have been considered: the physical significance seems to have been overlooked entirely. Probably this is due to the fact that the consensus of opinion at the present time seems to be that entropy has no physical meaning—that it is nothing more than the name which Clausius gave to the expression $\int \frac{dQ}{T}$.

Since my first article attempts to point out what entropy really stands for in a physical sense, it seems necessary to re-develop the definition in the same way as it was developed originally, but with special emphasis on the physical significance of each step involved.

A clear understanding of thermodynamics, and of entropy, requires an appreciation of the fact that rejection of heat to an external substance, and therefore waste of heat, accompanies every practical attempt to obtain work from heat. In the gas engine and in the non-condensing and jet condensing steam engine the working substance is thrown away with the heat; in the steam engine employing a surface condenser only the heat is rejected, the working substance being retained for future use; in all heat motors heat is rejected in one way or another.

Carnot has shown that if a quantity of heat Q is absorbed by a working substance at a constant temperature T, and if the waste may be rejected at a constant temperature T_0, then the maximum work obtainable from the heat Q is $\frac{T - T_0}{T} Q$. The minimum waste is obviously $Q - Q\,\frac{T - T_0}{T} = Q\,\frac{T_0}{T}$

Now any conclusion based on the assumption that heat is absorbed at constant temperature would not necessarily be true when heat is absorbed at varying temperatures—a thermal condition characteristic of all working substances, particularly of the most common working substance of all—steam. In the process of making steam, the temperature of the feed water increases with the heat absorbed until steam temperature is reached, after which it remains constant during evaporation and then rises again during the period of superheating. Hence, in order that our definition of entropy may be broad enough to cover the actual working substances met with in practice, it should be based on the assumption that the temperature of the working substance varies during the whole or any part of the period of absorption.

Consider such a working substance, and the small amount of heat dQ (equal to an infinitesmal in the limit) which is absorbed at any instant, and therefore at a practically constant temperature T. According to the Carnot principle the minimum amount of this heat which must be rejected is $\frac{T_0}{T} dQ$. If the unavoidable waste for each small amount of heat absorbed is $\frac{T_0}{T} dQ$. then the total unavoidable waste L for the total heat absorbed is therefore the summation of all the small elements of waste. Employing the calculus and assuming that the temperature at rejection remains constant, we have

$$L = \int_0^Q \frac{T_0}{T}\, dQ = T_0 \int_0^Q \frac{dQ}{T} \text{ or } \frac{L}{T_0} = \int_0^Q \frac{dQ}{T}$$

Now $\int_0^Q \frac{dQ}{T}$ is what is known as "entropy," and the physical meaning of its equivalent is interpreted as follows:

In the conversion of heat into work, whether of heat external to a working substance or contained within it as intrinsic energy, entropy is the minimum unavoidable waste per degree of the absolute temperature at which all of this waste may be rejected by the working substance.

It should be observed that I have not said that entropy is the minimum unavoidable waste divided by the absolute temperature at rejection; but that entropy is the minimum unavoidable waste per degree of the absolute temperature at rejection. The question is—has "minimum unavoidable waste per degree of temperature at rejection" any physical meaning?

That unavoidable waste is a perfectly familiar physical entity cannot be denied. We are conscious of it through the sense of sight and the sense of feeling. For what purpose is a condenser if not to abstract unavoidable waste heat? Temperature is likewise a perfectly familiar physical entity; and, since we know that the amount of heat rejected by an engine varies in some way with the temperature at rejection, why is not "unavoidable waste per degree of temperature at rejection" a strikingly significant physical conception?

Consider the analogy between velocity and entropy. Velocity is the ratio of two physical entities—distance and time; entropy is the ratio of two physical entities—rejected heat and absolute temperature; velocity determines distance passed over, and is itself determined by the motive power which produces it; entropy determines unavoidable waste, and is itself determined by the law of heat absorption. The fact that the velocity of an automobile is determined by the size of the engine is not an obstacle to our thinking of the velocity as the distance passed over per unit of time; the fact that the law of heat absorption $\int \frac{dQ}{T}$ determines entropy should therefore not prevent us from thinking of entropy as unavoidable waste per degree of temperature at rejection. There are two aspects for any physical property—the cause and the effect. What we know of most physical properties is through the effect. It is the same with entropy.

A consideration of what has been said thus far

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[1] Journal of Electricity, Power and Gas, Dec. 3, 1910.

[2] Engineering News, Sept. 1, 1910.

might lead one to infer that this conception of entropy applies only to those limited cases where the state of the working substance passes through a complete cycle of change. A reference to the original article will disclose that this conception has a much wider application. In this article I have shown that in the process of obtaining work by degrading a substance from one thermal state to another, the minimum unavoidable waste per degree of temperature at rejection is the entropy of the heat required to restore the working substance to its initial state—this entropy, or relative waste, being independent of the path by which the substance attained its initial state and likewise independent of the path by which it attains its final state provided only that heat is rejected at some constant temperature. It is thus seen that the definition of entropy advanced is as applicable to the simplest of thermal changes as it is to the complex changes involved when work is done by a cyclical process.

Consider the numerical value of $\int \frac{dQ}{T}$. It is determined by the amount of heat absorbed, which tends to produce a thermal change of state; and by the temperature during absorption, which is determined by the inherent characteristics of the substance, and is a factor in determining change of state for the heat absorbed. Entropy is therefore a function of the change of thermal state of a substance and, hence, a property of matter. From what has been said thus far it follows that—**Entropy is that property of matter which determines the least amount of heat which must be rejected to an external substance during any change of thermal state.** It is numerically equal to the summation of the quotients of the elements of heat required to reverse the change of state divided by the respective temperatures during absorption, that is $\int_0^Q \frac{dQ}{T}$. In a physical sense it represents the least amount of heat which must be rejected for each and every degree of the absolute temperature at rejection.

Thus entropy, as a property of matter, is no more difficult to understand than velocity, specific heat, electrical capacity, electrical potential, and the numerous other physical conceptions concerning which there is no mystery. Assuming that the assumptions and mathemathical processes employed in the development of this definition of entropy are valid, it is seen that there is no more "ghostliness" about entropy than there is about any of the other terms just enumerated. It is a simple conceivable property of matter which enables us to appreciate the possibility of obtaining work from heat.

To test our grasp of the physical significance of entropy let us consider a few problems.

A pound of air is heated at atmospheric pressure from 100 to 200 degrees Fahrenheit. What does the change of entropy signify?

It has been shown that change of unavoidable waste is associated with change of thermal state. An increase in the thermal state of a substance makes that substance liable to an additional increase in the amount of unavoidable waste—the relative increase is the "change of entropy." For the change of thermal state under consideration the change of entropy is

$$\int_0^Q \frac{dQ}{T} = \int_{T_1}^{T_2} C_p \frac{dT}{T} = C_p \log_e \frac{T_2}{T_1}$$

$$= .2375 \log_e \frac{200 + 459.5}{100 + 459.5} = .039 \text{ B. t. u.}$$

per degree Fahrenheit absolute, assuming that C_p, the specific heat at constant pressure, is constant, which is approximately true in practice. Thus an additional unavoidable waste of .039 B.t.u. per degree of absolute temperature at rejection is the result of heating the air to 200 degrees Fahrenheit. This must be incurred if the air is degraded back to its initial temperature, and will be the additional relative unavoidable waste if the air is degraded below this temperature, provided all waste is rejected at some constant temperature.

Problems of more practical interest are the following: What is the minimum steam consumption and the maximum thermodynamic efficiency of an engine operating on dry steam at 165 pounds absolute running non-condensing? What would be the theoretical saving by running condensing, assuming a vacuum in the cylinder of 25.85 inches? Feed water will be taken at 180 degrees Fahrenheit in the first case and at 120 degrees Fahrenheit in the second case.

It is not difficult to see that the most efficient way to utilize steam is by employing what is known as the Rankine cycle. In this cycle the working substance is initially water at exhaust temperature and pressure. The water is compressed to boiler pressure, heated to steam temperature, and evaporated into steam at this temperature. Adiabatic expansion then takes place until exhaust pressure is reached, after which the condenser abstracts the total heat of vaporization and returns the substance to its initial state as water at exhaust temperature and pressure. The work done is equal to the heat added minus the heat rejected. Since we must know the entropy to calculate the rejected heat, we must first develop the formula for the entropy of steam.

$$\text{Entropy} = \int_0^Q \frac{dQ}{T} = \int_0^{Q_1} \frac{dQ}{T} + \int_{Q_1}^{Q} \frac{dQ}{T_1}$$

$$= \int_0^{Q_1} \frac{dQ}{T} + \frac{Q - Q_1}{T_1} = \int_0^{Q_1} \frac{dQ}{T} + \frac{r}{T_1}$$

where r is the latent heat of vaporization, $\int_0^{Q_1} \frac{dQ}{T}$ is what is known as the "entropy of liquid" and $\frac{r}{T_1}$ as "entropy of vaporization." The values of these expressions for different steam pressures have been calculated and tabulated by Peabody and others and hence are readily available for the solution of problems.

In the Rankine cycle for the non-condensing steam engine, heat is employed to raise water from 212 degrees Fahrenheit to dry steam at 165 pounds absolute. The heat required per pound is 337.7+855.9—180.3, or 1013.3 B.t.u. The entropy is 0.5235+1.0370—0.3125, or 1.248 B.t.u. per degree Fahrenheit absolute. The absolute temperature at exhaust is 212+459.5, or 671.5 degrees Fahrenheit absolute.

By definition, entropy is minimum waste per degree of exhaust temperature. Hence, if the waste per degree is 1.248 B.t.u., the total waste for 671.5 degrees is 671.5×1.248, or 838.0 B.t.u. The work per pound is the difference between heat added and rejected, or 1013.3—838.0, or 175.3 B.t.u. Since one h.p. hour= 2545 B.t.u., this corresponds to a minimum steam consumption of $\frac{2345}{175.3}$, or 14.5 lb. per h.p. hour.

For the condensing engine the working substance would be raised from water at 126.3 degrees to dry steam at 165 pounds absolute. The heat required is 337.7+855.9—94.3, or 1099.3 B.t.u. The entropy is 0.5235+1.0370—0.1756, or 1.3849 B.t.u. per degree Fahrenheit absolute. The absolute temperature at ex-

haust is 126.3+459.5, or 585.8 degrees Fahrenheit absolute. Since the entropy, or relative waste, is 1.3849 B.t.u. per degree, the total waste for 585.8 degrees is 585.8×1.3849, or 811.3 B.t.u. The total work per pound is, therefore, 1099.3—811.3, or 288.0 B.t.u.; and the maximum steam consumption is $\frac{2545}{288.0}$ or 8.8 lb. per i.h.p. hr.

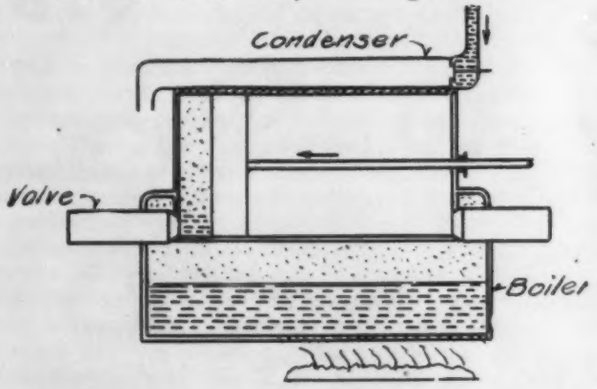
So far, the feed water temperatures have not been considered, since they affect only the heat (fuel) consumption and not the steam consumption. For the non-condensing engine with feed water available at 180 degrees Fahrenheit, the heat required is 337.7+855.9—148.0, or 1045.6 B.t.u. per lb. The work per pound according to the Rankine cycle is 175.3 B.t.u.; and the thermodynamic efficiency is $\frac{175.3}{1045.6}$ or 16.8 per cent.

In the case of the condensing steam engine, feed water is available at 120 degrees Fahrenheit, and the total heat required is therefore 337.7+855.9—88.0, or 1105.6 B.t.u. per pound. The maximum work per pound is 288.0 B.t.u. and the thermodynamic efficiency is $\frac{288.0}{1105.3}$ or 26.2 per cent.

The heat consumption per i.h.p. hour in the non-condensing engine is 14.5×1045.6, or 15,161 B.t.u. The heat consumption per i.h.p. hour for the condensing engine is 8.8×1105.6, or 9729 B.t.u. The theoretical saving by running condensing is therefore

$$\frac{15,161-9729}{15,161} \text{ or } 35.9 \text{ per cent.}$$

The practical man may remark: Assuming that all this is so, of what use are the results since they hold only for the perfect steam engine? To the engineer and the conservationist they mean a good deal.

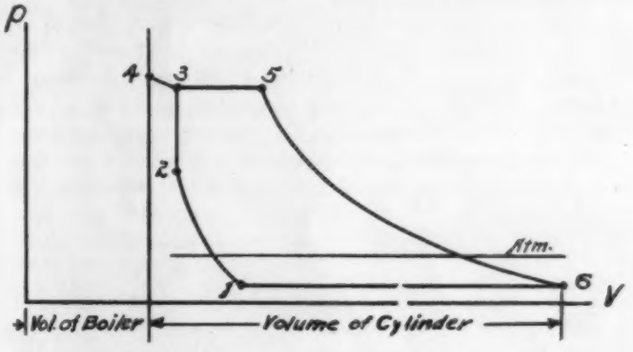


We have just seen that the perfect condensing steam engine operating under practical conditions has a thermodynamic efficiency of 26.2 per cent. Assuming a furnace efficiency of 70 per cent, the efficiency of the perfect engine in terms of the fuel consumption would be .70 x .262 or 18.3 per cent. A good compound condensing steam engine plant will produce an i.h.p. hr. on about 15 pounds of steam at its most economical load. Since the ideal steam consumption is only 8.8 pounds, this plant is utilizing only $\frac{8.8}{15}$ or 58.6 per cent of the theoretical efficiency. The plant efficiency is therefore .183-x .586 or only 10.7 per cent—a rather striking example of actual waste. Herbert Spencer has said, "Science is prevision." The conception of entropy enables us to appreciate the imperfection of our present day power plants with eyes wide open.

The student of theoretical thermodynamics may be interested in the accompanying sketch which shows a mechanical arrangement for a perfect steam engine and an indicator diagram supposedly taken therefrom. The diagram is the working cycle, and its efficiency is the ideal efficiency for the thermal changes involved.

Strictly speaking, a complete engine consists of a boiler, working cylinder, condenser, air pump and feed pump. The engine itself may do the work of the feed pump and air pump as in the accompanying sketch. This is accomplished in practice by driving the feed and air pumps from the engine shaft. Clearance space exists for mechanical reasons only and need not be considered in the perfect engine. Of course the engine is assumed to be made of material which is a non-absorber of heat, and the condensing surface is supposed to be a transmitter only when in use; hence there can be no cylinder condensation or conduction of heat except to the condenser. Owing to the location of the condenser only one end of the cylinder can be used at one time but this can be done by employing a heavy fly-wheel.

The operation is as follows: The initial position of the piston is as shown in the sketch, and is represented by 1 on the diagram. The condenser has just been cut out and the mixture of steam and vapor is about to be compressed. At point 2 the mixture has been compressed to water, and further compression compresses it to boiler pressure at 3 when the steam valve opens and the water is pushed into the boiler until the end of the stroke 4 is reached. The steam in the boiler expands and forces the piston back to the point 3, and from this point to the point 5 the water is heated to



and evaporated at steam temperature. At 5 the valve shuts. The weight of steam in the cylinder is exactly equal to the weight of water originally injected into the boiler and the steam in the boiler is at its initial quality and pressure. Adiabatic expansion then takes place to 6 when the condenser is put into service and abstracts heat at a constant pressure and temperature until the initial state 1 is reached when the condenser is cut out and the cycle is repeated over and over again.

For fixed steam and exhaust pressures the work done in this cycle may be varied by varying the compression, being greater or less according as the compression is greater or less. The heat required will be less as the compression is greater but, since it is more economical thermodynamically to use heat instead of work to raise temperature, the maximum thermodynamic efficiency will be obtained when there is no compression—in which case the cycle becomes identical with the Rankine cycle which has been employed in solving some of the above problems.

DISCUSSION OF PAPERS AT EIGHTEENTH ANNUAL CONVENTION PACIFIC COAST GAS ASSOCIATION.

The Oil Situation from the Gas Man's View Point.

Mr. Fitzsimmons: The paper just read covers the situation of the oil production in California very completely. However, aside from the production of oil in these oil fields today, that which should be most interesting to the members of the association is the production of natural gas, which was not mentioned in the paper read. There is now one well in the oil fields of California that is producing enough gas to supply the entire State of California. So that the possibilities of a large production of natural gas in this State are equally interesting to the members of this association as the production of oil. With the present equipment and facilities, of course, this gas could not be used for lighting purposes.

Mr. Collins: Gentlemen—This is one of the most alarming statements that has come before us since I have been at the convention. I would like to hear every word of it. Don't let it drop because all of us want to hear all about the situation. If an enormous quantity of natural gas is used in one location, it will probably shut down some of the great plants, and we want to know all of the facts. When a man goes into battle, he wants to know the power of his enemy. If we are going to combat it at all, we want to know all the features of it. I have heard some of it, and I want to hear it all, no matter how bad it is; I believe everyone within the hearing of my voice wants the information I desire. Therefore, will you kindly tell us these facts according to your own observation or experience? I would like to know them, so we can all have the benefit of them. We want to be prepared to meet the enemy or utilize it, whatever the case may be.

A Member: With regard to the gas well mentioned, there is but little that the gas men of the Pacific Coast need to fear. The Texas field was ruined, or practically ruined, by the presence of natural gas, yet there is, no doubt, a gas plant being erected almost each month in Texas, for the manufacture of artificial gas. The same is true of Louisiana, where there are also large fields. It has been stated that the gas produced in this well is not gas; it is vapor. It has considerable value as a heat generator if it could be utilized, but it could not be transported any great distance without a good deal of expense. Last, but not least, we must take into consideration the power of the great Owens river. The Owens river supplies lots of water for the city of Los Angeles, and in this regard we must not overlook our own interests. The fact is, that the greater the amount of water brought down, the greater the demand. A subject not to be forgotten is that expensive gas mains are required to conduct natural gas under high pressure, and it costs more, I think, than it would to conduct artificial gas under similar pressure. Different stoves are needed to utilize natural gas, and they cost more money. And don't forget that the men who bring natural gas from this wonderful well for you and me will not give it away; he is going to charge money for it. His development of the system will cost a tremendous amount of money. I think that the logical contention over all arguments of this character is to get busy and develop our plants to the highest state of efficiency.

Mr. Lowe: I heartily agree with the remarks of the last speaker, but nevertheless it is necessary for us, as gas men, to take cognizance of every existing condition. If there be 45,000,000 feet of combustible vapors going to waste in the Midway field, and it is to continue to flow 45,000,000 feet, or only one-tenth of that sum, someone is going to find a way to fix that vapor into gas and bring it into our large cities. We must be afraid; we must take cognizance of every existing condition, and there is no one in this world so greatly fooled as he who fools himself. If we have large fields of good natural gas, that is the product that we, as gas men, want. We have our distributing mains, we have our services, our meters, and we want that gas in them. We welcome the man who will deliver it, and if he cannot find the money, we will help find it for him.

Mr. Martin: I am a stockholder in an oil company that has a well in the Midway field. But there is no such pressure as they have. The pressure is 350 pounds to the square inch. There is not a holder there who wouldn't prefer to pump his oil and sell it, than burn it under his boiler, if he could get something for it.

Mr. Berkley: If our friend from Inglewood will look at what is being done in the Louisiana fields, he will see there is a pipe line 243 miles long reaching Little Rock, Arkansas, and distributing gas under high pressure. If the quantity of natural gas in the field, of which our friend has just given the figures, is anywheres near that, I assert that we ought to get in line. It is cheaper for us even at the present selling price, as much as we pride ourselves in manufacturing, and I would welcome natural gas under right and proper conditions. I know nothing of the field beyond what I have read of in the last three months. I believe it is a transportable gas in its present state, and will not require changes to be made so that it can be transported.

Several years ago the Indiana fields furnished a rock pressure of 450 pounds, and gas was transported to Indianapolis through a hundred miles, or more, of pipe. At that time the city had a population of nearly 200,000, and for a period of about twelve years hardly a carload of coal was sold for domestic purposes; there was not even a boiler from the street cars down that was not operated by natural gas. All of the large mills and foundries, such as the Indiana Car & Foundry Company, used natural gas. Therefore, I do not think there is any question about the right and proper consideration of this subject, and if there is such a quantity, and it is obtainable, it is up to us to get it.

Mr. Schade: I would like to ask Mr. Enger to give us his opinion. He has traveled extensively and is undoubtedly familiar with all the natural gas conditions of the country. I would like to ask him to give us his opinion.

Mr. Enger: My opinion, I am afraid, is rather a childish one. There is one aspect of that pipe to St. Louis, that is in regard to getting the franchise, and there is this: that they could make gas in St. Louis for less than they could get the natural gas. But my point which is rather childish is that in Kansas some time ago, there was a great discussion in regard to a well, which spouted how many million feet, but it got away from them, and after about six weeks they captured it again. I told some friends of mine that they were going to have an earthquake, and it happened that only a few days after that the earthquake at San Francisco occurred. My theory was this: You all are familiar with the air lock and know how they are applied to keep water out of natural gas, and it was on account of the pressure, and it was suggested that the State legislature of Kansas adopt measures to compel people to use natural gas to save their lives and property. This is just a theory but there is something in it. However, I think I might say that you could advance a great deal in the manufacture of gas in this section. There is a great deal more to be done. But I want to repeat something that I said yesterday. I didn't come here to speak, I came here to learn. I am not prepared to say much, but I have learned a great deal since coming here, and if it hadn't been for my friend Mr. Schade over there, I wouldn't have said anything about this earthquake. It is my theory and no joke at all. I say though, that you could improve your plants to make more from the oil than you do. It may be possible to make gas from oil for less money than it would be to pump natural gas and give it away.

Mr. Britton: I am impressed very much this morning by this discussion, because it takes me back a great many years, before a great many men in the gas business here were out of their swaddling clothes. Away back in the early part of '80 and the latter part of '70, the gas men of that day became very much agitated over the advent of electric lighting. Their doom in their own minds was assured. They thought they saw disaster staring them in the face. The board of directors met as usual, and with blanched faces awaited the blow which was to kill them. Their stocks and their bonds went down from above par,

to almost any price which anyone was willing to take them for. History is today repeating itself. The men who were fortunate enough to buy stocks and bonds of the gas companies that were depreciated, have made millions out of their investments. Now I don't want to see riot run here this morning, I don't want to see everybody become pessimists, merely because of the fact that a gas well has been discovered in Southern California, capable of producing enough gas to supply the entire State of California. I think we have merely to look over history, the history of the introduction of natural gas in Eastern States, in order to assure ourselves that we will be in the gas business long after the gas wells have died a natural death. The advent of natural gas in the Eastern States, and the advent of natural gas in California, has done nothing more than to increase the efficiency of the legitimate gas manufacturer. We have it around San Francisco Bay; it has been recently discovered in Sonoma County, and at Paloma, and it has not hurt the legitimate artificial gas industry in any way, nor can it. We also have it in Stockton, and Sacramento; not in limited quantities, but enough to supply the needs. It has been well said that the gas companies here today, with their present development and their plants and systems, are the natural distributers of that commodity, whether it be natural or artificial. The uses of natural gas are to a degree limited. It cannot possibly drive us out. The artificial gas companies, in the midst of the gas fields in this district have continued to increase their output, year by year. It would be impossible in my judgment and observation of the use of natural gas, to supplant the use of artificial gas entirely. It seems unlikely, that even if the amount of natural gas discovered here should be supplemented by other wells than those in the Midway field, it would never take the place of artificial gas, for the reason that every gas plant in use today, is constructed for the use of artificial gas, and would have to be changed and altered, to meet the conditions of the different character of gas that comes with natural gas. If they do come into the field, they will look, in my judgment, to the use of it in a way that the artificial gas companies have never been able to reach, and that is in larger industrial plants. They will consider the market for oil, and it seems to me that the people who control these fields are not going to cut off their nose to spite their face. These people have a tremendous output of oil, as evidenced by Mr. Burkhart's paper, and by their own admission, and the uses of natural gas, in competition with their own oil output must react upon their financial investment. They cannot throw one pet to take up another. There is more money in the oil business, and there is more money for the transportation companies than there would be in the transportation of natural gas. Now, we all know, at least those who are familiar with gas manufacturing, that the lowest or best cost to all of the companies in the manufacture and distribution of gas, is in its manufacture. The minimum part of the expense is there, The maximum part of the expense is in the distribution, organization, management, development and utilization of gas. The expense of delivering natural gas from fields four or five hundred miles away is obvious to you who know anything of the expense of its delivery to distant points. I am not afraid of the advent of this foe, so far as the legitimate development and manufacture of gas is concerned today, than twenty-eight or thirty years ago, did the advent of electric lighting. It will be but another prod in our side, to spur us on to the further development and utilization of the products that we have for sale. When you consider that in the United States today, that notwithstanding the combination of the companies interested in gas and electricity, that the gas sales have progressed equally with the sales of electricity, and that today, I have no doubt the testimony of the members will bear me out, that those engaged in the business of gas and electricity, that their gross annual revenues from gas equal, if not exceed, that of electricity, and better than that, in the plants which sell both gas and electricity, the profits arising from the sale and distribution of gas far exceed the profits derived from the generation and sale of electricity. I think that our Alma Mater is safe in our hands. I do not believe that the new born child coming in today can take our place, or drive us out of business. I don't want to see gas men become pessimists; I would rather see every gas man become an optimist on the question of the manufacture and distribution of artificial gas in the State of California.

NEW CATALOGUES.

Bulletin No. 129 from The Electric Storage Battery Co. describes the installation of a storage battery for the New River and Pocahontas Consolidated Coal Company. This is one of the few battery installations for this purpose, and the charts show the results that have been accomplished by the use of a battery.

Ad Book No. 22 just issued by the Westinghouse Electric & Manufacturing Company, contains a series of attractive advertisements suited to the use of central station companies that are anxious to boom Christmas trade in electrical appliances. Every "ad" in the book contains a reflection of the spirit of the Christmas season.

Bulletin No. 4782, just issued by the General Electric Company, entitled "Direct Current Exciter Panels," illustrates and describes exciter panels for use in connection with alternating current generator panels when for any reason separate control of the exciter is desired. The bulletin contains a complete description of these panels, also diagram of connections and dimensions.

"Type MW Slip Ring Induction Motors" is the title of Circular No. 1188. just issued by the Westinghouse Electric & Manufacturing Company, Pittsburg, Pa. The circular describes a line of Westinghouse alternating current slip-ring motors designed especially for cranes, hoists and elevators. Reference is made also to suitable controlling devices and brakes.

The General Electric Company has just issued a booklet describing Miniature Decorative Incandescent Lamps. The lamps are illustrated in color, and various designs representing fruits and flowers are shown. These lamps are used for decorating Christmas trees and also in connection with set pieces of artificial shrubs, trees, etc. The number of the booklet is B-3004.

The General Electric Company has recently issued pamphlet B-3006, which is a reprint of the paper read before the National Electric Light Association on the subject of "Street Illumination." This pamphlet compares the results obtained from the use of luminous and flame arcs with those resulting from the use of open and enclosed carbon arcs. The subject is treated from the standpoint of the illuminating engineer and is discussed in detail. The pamphlet contains half-tone illustrations showing street illumination by luminous arcs in various cities. There are also numerous diagrams. The subject is treated exhaustively and should be of great interest and assistance to all interested in this branch of engineering.

The Western Electric Company has just issued its Bulletin No. 5500, describing Hawthorn direct and alternating current enclosed arc lamps. The bulletin contains twenty pages and is well illustrated with many photographs, diagrams and tables. Separate pages are devoted to direct current multiple enclosed arc lamps, including the marine type, for 100 to 125 volt circuits; direct current multiple enclosed arc lamps, including the mill type, for 200 to 250 volt circuits; power circuit lamps, direct current enclosed arc lamps for power circuits, alternating current multiple enclosed arc lamps for circuits of 100 to 125 volts, 200 to 250 and 400 to 460; direct current series enclosed arc lamps for 6.6 ampere circuits, alternating current series enclosed arc lamps for 6.6 and 7.5 ampere circuits, Solaris arc lamps, both alternating current and direct current, and arc lamp accessories.

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NOTICE TO ADVERTISERS

Changes of advertising copy should reach this office *ten days in advance of date of issue*. New advertisements will be accepted up to noon of Monday dated Saturday of the same week. Where proof is to be returned for approval, Eastern advertisers should mail copy at least thirty days in advance of date of issue.

Entered as second-class matter at the San Francisco Post Office as "The Electrical Journal," July 1895.
Entry changed to "The Journal of Electricity," September, 1895.
Entry changed to "The Journal of Electricity, Power and Gas," August 15, 1899.
Entry changed May 1, 1906, to "The Journal of Electricity, Power and Gas," Weekly.

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Trees and Water

If the ancient Arabian nature-faker who perpetrated that poetic prevarication, "the tree is the mother of the fountain" were now living in some parts of our western country, where every drop of water is more precious than it ever was in the deserts of Arabia, he would soon find himself the most unpopular citizen in the township. If he could be shown that every lofty pine on the mountain top deprives an orange grove in the thirsty valley of needed sustenance, he needs must confess that he grossly exceeded the elastic limits of even poetic license. He mistook effect for cause. The tree may be the child of the fountain but never the mother.

From his mistake it is an easy transition to the universal misconception that forests always exert a beneficial influence on stream flow. So firmly is this false idea engrafted in the public mind that the engineer who substitutes fact for surmise and who proves that in many places the forests absorb much carefully conserved moisture is at once regarded as an enemy to mankind. We admit that these statements are startling and revolutionary, that they are contrary to all preconceived notions and upset many well-laid plans, but nevertheless they are facts. Careful observation has shown that on the Pacific Coast heavy forests are more often detrimental than beneficial to the even regulation of water flow.

More than two years have elapsed since Col. H. M. Chittenden presented a paper before the American Society of Civil Engineers, wherein he demonstrated that in the Cascade and Sierra Nevada Mountains forests prevent the formation of snow drifts and expose large snow surfaces to undue evaporation. Since that time the only refutation of his arguments is that they are not of general application and that in many special localities, particularly in Eastern states, the reverse appears true. In the resulting discussion many additional facts were presented to strengthen the original argument. Mr. W. H. Leffingwell and A. M. Strong, especially, showed that, whereas the drainage areas of the Merced and Kings Rivers were heavily timbered, these same rivers are subject to much greater fluctuation than the Kern and Owens Rivers which have little or no forest cover. It is demonstrated that entirely too much credit is assigned to the sponge action of the forest floor and that heavy brush is just as effective in retaining the greatest possible volume of water until such time as it is most needed for irrigation. It has also been established that the great expanse of ice and snow above the timber line is the reservoir supplying most of the water in the late summer months.

It was not the purpose of these engineers to discourage tree planting in the right places but only to make clear that the irrigation and power needs of the West are different from the navigation and power interests of the East. With thousands of square miles of arid land which needs but the magic touch of the water to become the most fertile in the world, it seems just that the demands of forestry should give way to the needs of agriculture.

PERSONALS.

R. J. Buck of Sanderson & Porter is in New York.

A. J. Turner, engineer for the San Dimas quarry at San Dimas, Cal., is visiting San Francisco.

F. N. Jewett, general sales manager of the Wagner Electric Company has returned to St. Louis via Los Angeles.

Rudolph W. Van Norden, consulting civil and electrical engineer, returned to San Francisco from Los Angeles this week.

A. A. Young of the von Hamm Young Co. of Honolulu is at San Francisco making his headquarters with T. F. Dredge in the Metropolis Bank Building.

W. S. Atkinson has resigned as chief draughtsman for C. C. Moore & Co., to take a similar position with the Yuba Construction Company at Marysville, Cal.

W. R. Wheaton, formerly with the U. S. Forestry Service, is in charge of the new pole creosoting plant of the San Joaquin Light & Power Company, at Fresno, Cal.

Henry Bosch, assistant engineer of electrical construction for the Pacific Gas & Electric Co., has recently returned from an extended tour of eastern power plants and factories.

L. B. Cramer, electrical engineer of the Oregon Electric Railway Company and chairman of the Portland Section, A. I. E. E., was recently appointed electrical engineer of the United Railroads Company of Portland.

J. C. Farrar, formerly electrical engineer with the Buick Motor Car Company at Flint, Mich., has opened offices as consulting, constructing and contracting engineer in the San Fernando Building, Los Angeles, Calif.

H. M. Fennemore, division commercial superintendent of the Rocky Mountain Bell Telephone Company recently visited Logan, Utah, and completed preparations for removing the billing and accounting department for the northern part of the State from that point to Ogden.

A. C. Sprout spent the past week on the San Joaquin River in connection with the installation of a reclamation pumping plant on the Webber Tract. Current will be taken from the Pacific Gas & Electric Company's transmission lines to operate a Westinghouse motor direct connected to a Samson centrifugal pump.

Wynn Meredith, Pacific Coast manager for Sanderson & Porter of New York, returned last week to his San Francisco office, after spending several months in the Pacific Northwest. Most of the time was spent on Vancouver Island in connection with the construction of the Jordan River hydroelectric plant of the British Columbia Railway, Light & Power Company, which will transmit current to Victoria, B. C.

Newly elected associate members of the American Institute of Electrical Engineers include L. W. Allison, draftsman, Pacific Light & Power Company, Los Angeles, Cal.; R. M. Cobb, construction foreman line department, Pacific Electric Railway, Los Angeles; G. E. Fairly, electrician, Los Angeles, Aqueduct, Saugus, Cal.; L. D. A. Gain, electrical designer and draughtsman, Western Canada Power Company, Vancouver, B. C.; R. E. Jerauld, commercial engineer, General Electric Co., Salt Lake City, Utah; C. B. Johnson, construction foreman, General Electric Co., San Francisco; V. R. Marshall, station superintendent, Central Colorado Power Company, Dillon, Colo; F. P. Mooney, Arrowhead Reservoir & Power Company, San Bernardino, Cal.; L. L. Newcomb, electrical operator Nevada-California Power Co., Bishop, Cal.; E. S. Pridham, engineer Poulsen Wireless T. & T. Co., Stanford University, Cal.; D. L. Schaaf, chief operator Bay Shore sub-station, Sierra & San Francisco Power Co., San Francisco; R. H. Spencer, constructing electrician, Southern California Edison Co., Los Angeles, Cal.

Charles E. Wiggin has resigned his position with John R. Cole & Company to become general manager of the electrical department of Dunham, Carrigan & Hayden of San Francisco. Mr. Wiggin has been actively associated with the electrical business in San Francisco for over twenty years during which time he has earned the friendship of all with whom he came in contact. For the fifteen years from 1889

Chas. E. Wiggin.

to 1904 he was with Will & Finck. In 1904 with the co-operation of John M. Kline and George Greenwood he organized the Electrical Contractors' Association and has served as its secretary ever since. During 1906 he was with the Western Electric Company and later went with John R. Cole Company. Because of his extensive acquaintances throughout the electrical fraternity and his thorough knowledge of local business conditions he enters upon his new duties under unusually favorable conditions.

MEETING NOTICES.

The Los Angeles Section of the American Institute of Electrical Engineers meets at Blanchard Hall, 231 South Broadway, at eight p. m. on December 29th. Prof. R. W. Sorensen of Throop Polytechnic Institute will give a paper "Transformers and their selections." All members of the electrical fraternity who may be in Los Angeles on that date are cordially invited to be present and join in the discussion.

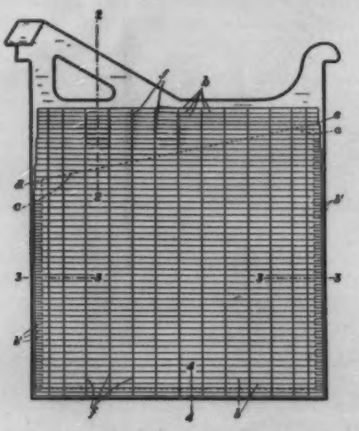
The Portland Section of the American Institute of Electrical Engineers met in the assembly hall of the Electric Building, on December 13, 1910. Mr. W. E. Evans of the electrical department of the Southern Pacific Company read a paper on the 1200 volt d.c. system of the Central California Traction Co. On January 17, 1911, E. J. Griffith will present a paper on Conservation of Natural Resources and on February 21, E. L. Ritter will speak on Telegraph and Telephone Work.

The San Francisco members of the American Society of Mechanical Engineers held a meeting in the assembly room of the Merchants' Exchange Building, on the evening of December 16th, for the purpose of discussing Pacific Coast Practice in the Use of Crude Petroleum for Fuel. Short discussions of the subject were read by Mr. Arthur F. Bell, Prof. J. N. LeConte, Mr. C. F. Weiland, Mr. C. R. Weymouth, Mr. K G. Dunn, Mr. J. H Hopps, Mr. A. M. Hunt and Mr. E. C. Jones, and the subject was discussed by many engineers present.

The Pelton Water Wheel Company has sold to the Utah Construction Company a 250 h.p. Pelton-Francis turbine which is to be direct connected to a Fort Wayne alternator and operated under an effective head of 80 feet. The plant will furnish current for electrically-driven hoists, air compressor and pumps at a mine in Idaho.

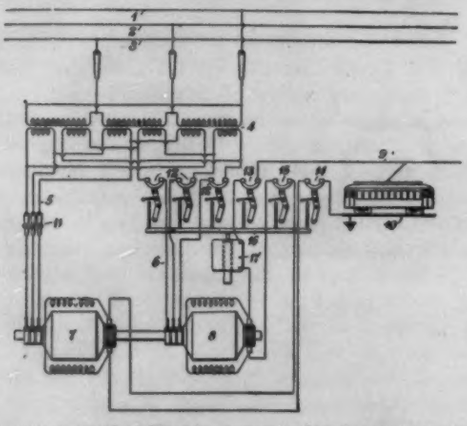
PATENTS

977,443. Storage-Battery Plate. Bruce Ford, Philadelphia, Pa. A storage battery plate consisting of groups of leaves united by ribs and having a marginal web, the ribs adjacent to web being spaced nearer together than the rest of the ribs



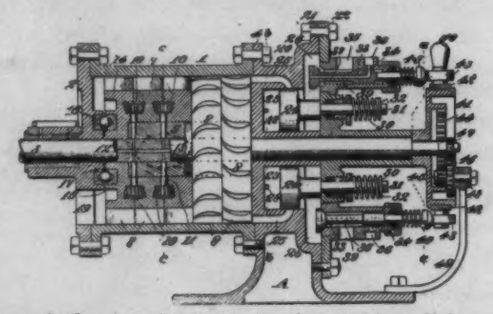
whereby the length of the span of the leaves which are attached to the web is decreased and the leaves are supported at closer intervals by the ribs to prevent their detachment from the web, substantially as described.

977,645. System of Distribution. Paul M. Lincoln, Pittsburg, Pa., assignor to Westinghouse Electric & Manufacturing Co. In a system of distribution, the combination with an alternating current circuit, a direct current circuit and two mechanically coupled rotary converters that are connected in



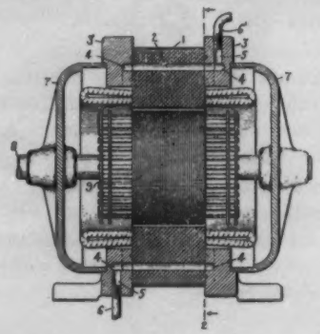
series relation to the direct current circuit and are independently connected to the alternating current circuit, of circuit breakers in the connections of one converter to the alternating current circuit, circuit breakers in the connections of the converters to the direct current circuit, and means for effecting simultaneous opening of all of the said circuit breakers.

978,044. Turbine-Motor and Pressure Device. Thomas J. Loftus, Castella, Cal., assignor of one-half to Charles T. Loftus, Castella, Cal., and one-half to Harmon Bell, Oakland, Cal. In a turbine motor, the combination of a turbine housing, a series of combustion chambers at one end thereof, means for delivering explosive fluid under pressure to said chambers, said means including air and gas inlets and normally closed valves controlling said inlets, means for operating the valves to permit the fluids to enter the explosion chamber, means for exploding said fluid in the chambers, said housing having passages connecting its interior with the explosion chambers, and horizontally slidable valves normally closing the inlet to said passages and actuated by the gases of the exploded charge to direct the exploded fluid to the



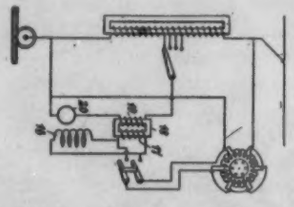
interior of the housing and to the turbine disks, a drive shaft adapted to be revolved by said disks, and connections between the shaft and the first named valves for operating the latter.

977,768. Dynamo-Electric Machine. John B. Wiard, Lynn, Mass., assignor to General Electric Company. In a dynamo electric machine, a stationary laminated core structure having a plurality of holes extending there-through for receiving a cooling fluid arranged in a circle, the interior walls of



said holes being coated or covered so that cooling fluid will not leak out between the laminations, and end frames clamping said core structure, each of said end frames having a circular groove registering with said holes and a channel connecting said groove to the exterior of said end frame.

978,038. System of Regenerative Control for Electric Motors. Benjamin G. Lamme, Pittsburg, Pa., assignor to Westinghouse Electric & Manufacturing Company. The combination with a dynamo-electric machine adapted for operation either as a motor or as a generator and provided with

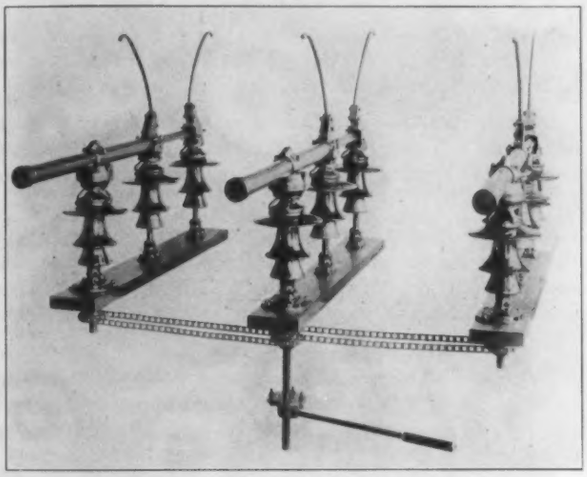


series-connected field magnet and armature windings, of a source of energy to be connected in shunt circuit to the field magnet winding when the machine is operated as a generator, the voltage of the source being approximately equal to the normal or predetermined drop of potential in the field magnet winding.

INDUSTRIAL

OUTDOOR DISCONNECTING SWITCH.

The accompanying illustration represents a photograph of one of a new line of outdoor disconnecting switches which the General Electric Company is prepared to furnish for use on circuits up to 110,000 volts. The entire line is high class in every particular, is thoroughly weather-proof and will act satisfactorily under all weather conditions. It should be particularly noted that this outdoor disconnecting switch does not in any way require special line construction, neither is it necessary to alter the spacing of the lines where they are connected to the switch since the contact blades in opening and closing move parallel to the direction of the transmission line.



Bolt Type, Outdoor Disconnecting Switch.

The illustration shows the switch closed. When the switch is opened all the blades move parallel to one another into the pipes. The blades are moved together by means of sprocket wheels and chains and a single operating handle which can be placed at any convenient point near the switch itself or close to the ground. The handle can be locked in the closed or open position.

The entire operating mechanism, including the sprocket and chains, is protected from the weather. The contacts are installed in housings and the switch cannot therefore be rendered inoperative by rain or snow.

The blades are so shaped that it is difficult for ice to form on them, but if this should happen, small wheels, which rest on the upper edge of the switch blades, serve to break this ice when the switch is opened, and thus keep it from getting into and clogging the mechanism of the switch.

The switch contacts are protected by goat horns, so that, in the event of opening magnetizing currents or larger currents accidentally, the contacts will be protected. That the switch is simple and substantial in construction can be readily seen from the illustration.

THE NEW WESCO CATALOGUE.

Catalog 150 of Electrical Supplies from The Wesco Supply Company of St. Louis is one of the most elaborate and comprehensive ever published. It contains 1324 pages, 8½ x11 inches and gives descriptions and prices of every conceivable kind of electrical apparatus. The illustrations and text are so detailed that it is really an encyclopedia of present day electrical practice. It begins with a thumb indexed sectional index and a general index of 21 pages. Many of the supplies listed are of Wesco make and the remainder are products of specializing manufacturers. This gigantic volume has been compiled by Mr. R. C. Mellor.

Apparatus described includes both large and small motors and generators, together with all accessory control, transforming and measuring equipment. To automobile ignition supplies 24 pages are devoted, 22 pages to electric heating devices, 14 pages to fans, 150 pages to fixtures and shades, 100 pages to house goods, including annunciators, batteries, bells, flashlights, medical batteries and speaking tubes, 20 pages to incandescent lamps, 22 pages to insulating materials, 60 pages to line construction materials, 22 pages to station supplies, 45 pages to street lighting supplies, 120 pages to street railway supplies, 65 pages to telephones and telegraph instruments, 55 pages to tools, 6 pages to electrical toys, 20 pages to wire and cable and 350 pages to wiring supplies. In all, there are over two thousand different kinds of apparatus and supplies listed.

In addition considerable general information and suggestions are given as well as a complete dictionary of phrases and code words, the code index alone occupying 115 pages. Many tables are included giving weights of all sorts of bolts, washers and screws. The metric units and their equivalents are given in detail as are also the standard electrical symbols and gauges. Electrical definitions and wiring computations of a practical nature are fully illustrated and explained.

TRADE NOTES.

H. T. Drennen will manage the electrical business of the firm of Davis & Drennen at 406 East Burnside street, Portland, as the firm was dissolved on November 1.

The Economy Electric Company has bought the electrical contracting business of Johnston and Sayre and will continue at 723 St. Helens avenue, Tacoma, Wash.

American Engineering Corporation has been organized with offices in the Mechanics' Institute Building, San Francisco, by C. E. Grunsky, L. W. Symmes, E. F. Haas, H. D. Connick, Loren E. Hunt, A. E. Chandler and Thos. H. Means to furnish specifications, reports, estimates, appraisals, superintendence, construction or operation in all branches of engineering.

Owing to greatly increased business the H. W. Johns-Manville Company announces the removal of its offices now located at 85 Sheldon street, Houghton, Mich., to more commodious and convenient quarters at 96 Sheldon street, where they will be better prepared to serve their patrons. As in the past, Mr. S. T. Harris, who has been associated with the Company for a number of years, will be in charge of the offices at the new address.

The Electric Storage Battery Company, through their Pacific Coast representatives, Pierson, Roeding & Co., are installing two large storage battery and synchronous motor generating sets to meet the hoisting requirements in Nevada mines. One order for 120 cells type G-35 "Chloride" accumulators and a 400 kw. synchronous motor generating set has been received from the Goldfield Consolidated Mining Company of Goldfield and the Tonopah Mining Company of Tonopah has also ordered 120 type G-31 "Chloride" accumulators to be supplied by a synchronous motor generator. These are in accord with the system of a. c. regulation which has rerently been devised by the Electric Storage Battery Co. The Southern Pacific Co. has also ordered exciter battery sets for its new Fruitvale and Oakland sub-stations.

NEWS NOTES

INCORPORATIONS.

KERMAN, CAL.—The Kerman Telephone Company has been incorporated with a capital stock of $15,000.

VALE, ORE.—Articles have been filed for the Farmers' Electric Railway Company with a capital of $50,000, to construct a 25-mile S. W. line from this place. R. H. Dearmont and C. W. Thomas are among the incorporators.

FINANCIAL.

ASHLAND, ORE.—The City Council has decided to call a special election for the purpose of submitting a bonding proposition to the amount of $170,000 on the waterworks extension project.

ESCONDIDO, CAL.—The directors of the Mutual Water Company have levied an assessment of 5 per cent upon the capital stock for further permanent improvements to the upper end of the water system. The assessment will raise $11,000.

SIERRA MADRE, CAL.—The City Council passed an ordinance calling a special election to be held here to submit to the voters the proposition of issuing bonds in the sum of $40,000 to construct a municipal water system in this city. The bonds will bear 5 per cent interest, payable semi-annually.

VICTORIA, B. C.—At the forthcoming civic elections, among other many laws to be submitted will be one to authorize the raising of $25,000 for the purchase of electrical equipment for the extension and improvement of the street lighting system rendered necessary by the rapid growth of the city.

OAKLAND, CAL.—The shareholders of the Oakland Traction Company will vote December 31 upon creating a new bonded debt to the amount of $250,000 for the purpose of purchasing rolling stock. Said bonds are to be additional to the $12,000,000 bonds issued and issuable under the general mortgage of 1907. The directors include: E. A. Heron, Dennis Searles, C. P. Murdock, S. J. Taylor, F. C. Havens, Geo. E. Pratt and Arnold E. Needham.

ILLUMINATION.

JACKSON, CAL.—John L. Henry has applied for a franchise to erect electric lines for all purposes in the county of Amador.

TOLEDO, WASH.—The Toledo City Council has passed an ordinance granting to E. P. Badger and A. R. Badger a franchise for lighting the town of Toledo with electricity.

LA GRANDE, ORE.—J. L. Lambirth, one of the best known electric and gas men in the Northwest, is in this city for the purpose of asking for a franchise to install a gas plant here.

LONG BEACH, CAL.—Secretary George H. Marshall of the Long Beach Consolidated Gas Company, has denied the report that $300,000 worth of bonds of the $1,000,000 bond issue provided for by the company would be sold at once for expenditure in building the proposed new plant here.

STAYTON, ORE.—A. L. Shrevo, proprietor of the Stayton Electric Light plant, states that he has just completed a deal for the purchase of a power site three miles up the Santian river from Stayton. The site is a valuable one and capable of generating about 5000 horsepower. Modern power houses will be built on the site, which is located on the north side of the river.

PORTERVILLE, CAL.—At a meeting last week of the local stockholders of the Home Gas Company at the office of Geo. G. Murry it was definitely decided to organize an entirely new corporation to be known as the Porterville Gas Company, the object being to take over the interests of T. J. Wright, who is the Los Angeles capitalist at the present in control of the corporation. F. H. Hess, the manager of the company and the secretary of the corporation will immediately take up the sale of the stock.

TRANSMISSION.

EUGENE, ORE.—The Oregon Power Company, will expend $1,000,000 on a large hydroelectric plant on the McKenzie river near St. Martin's rapids.

CLARKSTON, WASH.—The Lewiston-Clarkston Improvement Company is planning the construction of a hydraulic power plant on the Grande Ronde river of 10,000 h.p.

ASOTIN, WASH.—J. J. Jennings of the Lewiston-Clarkston Company is here looking for locations for power lines to conduct 150 h. p. to a pumping plant to be installed across the river.

MURRAY, IDAHO.—It is reported that the Thompson Falls Water Power Company is surveying a right of way from Thompson to Murray and Burke, and will stretch wires as soon as possible to furnish electric power to Idaho mines.

LONG BEACH, CAL.—The big contract for the erection of a reinforced concrete, brick, stone and steel building for the Edison Company's power plant on inner harbor has been let to the F. O. Engstrom Company of Los Angeles. The building is to be completed before February 1.

KENNEWICK, WASH.—The R. E. Downie Pole Company, 432 New York Building, Seattle, has been awarded a contract by the Pacific Power & Light Company, Portland, for the supplying of the transmission poles for the construction of a high power tension line from this city to Hanford, Wash.

PLACERVILLE, CAL.—Henry Lahiff has filed notice of location of 5000 inches of the water flowing in the south fork of the American river in township 11 north, range 16 east, and also 4000 inches of water in the south fork of the American river in township 11 north, range 155 east, said locations being for manufacturing and electric power purposes.

AMERICAN FALLS, IDAHO.—Thirty thousand additional horse-power is to be developed at American Falls during the coming year by the building of a new power station, which will constitute the main plant of the system as projected several years ago. Authority for the announcement comes from Governor Brady who controls all the stock of the Idaho Consolidated Power Company.

PAYETTE, IDAHO.—The Telluride Association states that within two months it will construct a plant near the confluence of the Malas and Snake rivers. The plant is to cost $2,000,000 and will generate 10,000 horsepower. J. J. Nunn, manager of the Gale Light Plant in La Grand, Ore., has been awarded the contract for constructing the plant which is to be completed by March 1, 1911.

LOS ANGELES, CAL.—Captain John Cross, railroad builder, has filed an action against the Vallejo, Benicia and Napa Valley Railway Company, W. F. Botsford, Arthur F. Hawse, John T. York, L. J. Perry, Z. T. Hatch, C. M. Hatch

and other individuals and banking concerns. He demands that $15,000 stocks and bonds of the Vallejo, Benicia and Napa Valley Company be returned to him, or judgment for their value be given.

REDDING, CAL.—The Commissioner of the General Land Office had decided the case of the Northern California Power Company against H. V. Gates, upholding the decision of the local land office officials which was against Gates. Gates sought a patent to a building-stone claim in the Big Bend of the Pit river, which is particularly valuable as a power-house site. He had located 20,000 inches of water and proposed digging a tunnel five miles long to get the necessary fall for the project. The decision is important, as 18 similar cases are pending in the Redding land office.

TRANSPORTATION.

SAUSALITO, CAL.—The Northwestern Pacific Railway Company is in the market for a 2000 kw. d.c. railway generator set for its Alto power station.

PHOENIX, ARIZ.—The Glendale electric line will be constructed as soon as all the rights of way have been secured by S. M. Mitchell, superintendent of road.

LOS ANGELES, CAL.—Construction work on the Los Angeles-Pacific's new line from Hollywood to Lankershim will begin as soon as contractors can get their equipment on the ground. The contract, amounting to $250,000 has been let.

FRESNO, CAL.—The further investment of $100,000 in the building of interurban lines in the country is announced, with the statement from F. S. Granger, of the Fresno-Hanford Interurban electric line, that $100,000 would be employed in the erection of a power-house for his road to be built a little north of Fowler, ten miles southeast of Fresno. Ground is to be broken in a short time on Granger's line, running south from Fresno by way of Fowler to Hanford, to tap the rich Kings river bottom country, in which also two steam lines are now competing for rights of way.

TELEPHONE AND TELEGRAPH.

SALMON CITY, IDAHO.—The Lemhi Telephone Company has been granted a franchise to put in a telephone system here.

ABERDEEN, WASH.—The construction of the telephone line from this place to Westport has started. It is financed by E. C. Finch.

NORTH YAKIMA, WASH.—Wm. J. Smith, district commercial agent of the Pacific Telephone & Telegraph Company, announces that a branch telephone service will be established here and other extensions and improvements will be made this winter.

NEVADA CITY, CAL.—Nevada City will have an opposition telephone service during the coming year, as it is stated that the Home Telephone Company is investigating the field. Some of the Nevada City merchants who have interests in Grass Valley, are planing the building of a private line between the two towns.

SAN JOSE, CAL.—The Pacific Telephone & Telegraph Company has instituted a new service between San Jose and San Francisco. The San Francisco telephone numbers are now given to San Jose subscribers by the local operators, which does away with the necessity of giving the numbers desired to long distance. Under the new system it is possible for a San Jose subscriber to talk to a San Francisco subscriber by simply asking for the San Francisco number. It is the system now in use between San Francisco and Oakland.

WATERWORKS.

GLENDALE, ORE.—The Glendale City Council will in the near future meet to discuss the bonding of the city in order to improve and enlarge the waterworks system.

PETALUMA, CAL.—Fire Chief Wm. Zartman in his monthly report to the board requests that the board consider the advisability of installing larger valves in the hydrants.

SAN LUIS OBISPO, CAL.—The Board of Trustees has accepted the proposition made by Frank Tate, who owns lands and rights needed by the city for a greater water system and will proceed at once with the work of building a new reservoir.

VICTORIA, B. C.—Bids addressed to R. Fowler, municipal engineer, law chambers, Bastion street, Victoria, B. C., will be received up to the 27th of December, for supplying British castiron water pipe and special castings. Tenders must conform with the terms of specifications.

VALLEJO, CAL.—Mayor J. F. Chappell, Commissioner of Public Works Blake, City Trustee Butler and City Clerk Tormey are all convinced that 1000 feet of 6-inch pipe will be sufficient to carry half of the water needed by the city. The city already has 600 feet of the required pipe.

NORTH YAKIMA, WASH.—A preliminary survey is being made by the Pacific Power & Light Company for extension to the city water main, which after the change, will take the water from the Naches river six or eight miles farther up than at present and will result in a more constant water pressure through the summer months.

MARTINEZ, Cal.—The Port Costa Water Works has remodeled and doubled the capacity of its plant in the past six months, laying about 5 miles of 18 in. delivering main from near Concord to Martinez, increasing its well supply, building a new pumping station with electrically operated pumps, the power being derived from the Great Western Power Company, and making many other improvements to increase service, all done under the direction of M. M. O'Shaughnessy, consulting engineer for the company.

MERCED, CAL.—A new concrete diverting dam has been built by the Crocker Huffman Land & Water Company across the Merced River. This dam is 700 ft. long with concrete abutments 14 ft. high, and contains about 7000 cubic yards of concrete. It was built and completed in the record time of four months from the date of commencement, which was about the 20th of August this year. It has 500 feet of steel collapsible gates in the center, which can lower the level of the water 4 feet, thus passing floods without swamping the country above. It was designed by M. M. O'Shaughnessy, consulting engineer, and built by the Pacific Construction Company. George Schussler was resident engineer.

OAKLAND, CAL.—That work would be commenced at once on the pipe distribution system of the Bay Cities Water Company in the city limits of San Leandro, was the announcement made at the meeting of the City Council of San Leandro last week. Col. M. M. Ogden of the Bay Cities Water Company states that the work would be rushed forward as rapidly as possible and that the company will be supplying water to its customers in San Leandro and East Oakland early in the coming spring. The new water company has also filed a bond for $5000 with the Board of Public Works of the city of Oakland to cover any damage that may result from excavating in the streets in laying the new pipe system. The company has already received 100,000 feet of cast-iron pipe, and over 200 carloads of pipe of various sizes from 4 to 12 inches will be here in ten days, and rushed out to sidings at Elmhurst, Fitchburg and San Leandro.

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Seattle, Alaska Bldg.
Portland, Couch Bldg.

Southern Pacific Co. 14
San Francisco, Flood Bldg.

Sprague Electric Co. 13
New York City, 527-531 W. 34th.
San Francisco, Atlas Bldg.
Seattle, Colman Bldg.

Standard Und. Cable Co. 1
San Francisco, First National Bank Bldg.
Los Angeles, Union Trust Bldg.
Seattle Office, Lowman Bldg.

Star Expansion Bolt Co. 5
New York City, 147-149 Cedar.
San Francisco, 1010 Howard.

Sterling Paint Company, 5
San Francisco, 118 First.

T

Technical Book Shop
San Francisco, 604 Mission.

Tel. & Elec. Equip. Co.
San Francisco, 612 Howard.
Los Angeles, Security Bdg.
Seattle, Alaska Bldg.
Portland, Couch Bldg.

Thomas and Sons Co., R.
New York, 227 Fulton.
East Liverpool, Ohio.

Tracy Engineering Co. 5
San Francisco, 461 Market.
Los Angeles, Central Bldg.

V

Vulcan Iron Works 1
San Francisco, 604 Mission.

W

Wagner Electric Mfg. Co. 1
St. Louis, Mo.

Western Electric Co. 4
San Francisco, 680 Folsom.
Oakland, 507 16th.
Los Angeles, 119 E. 7th
Seattle, 1518 First Ave. So.

Western Wireless Equipment Co. 5
San Francisco, Grant Bldg, 7th and Market.

Westinghouse. Elec. & Mfg. Co. 6
Pittsburg, Pa.
Los Angeles, 527 So. Main.
Denver, 429 17th.
Seattle, Central Bldg.
Salt Lake City, 212-214 So. W. Temple.
San Francisco, 165 2d.
Spokane, Columbia Bldg.
Portland, Couch Bldg.
Butte, Lewisohn Bldg.
Canada, Canadian-Westinghouse Co., Ltd., Hamilton, Ontario.
Mexico, G. & O., Braniff & Co., City of Mexico.

Westinghouse Machine Co. 6
Pittsburg, Pa.
San Francisco, 141 Second.

Weston Elect'l. Instrument Co. 4
Waverly Park, N. J.
New York, 114 Liberty.
San Francisco, 682-684 Mission.

Wilbur, G. A.
San Francisco, 61 Second.